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Welcome

It's business as usual... and we celebrate Hubble at 30!

As we go to press with this issue, we face big changes to our daily lives. For us all this means unprecedented restrictions on movement, both in our home and working lives, and that of course includes the team behind *BBC Sky at Night Magazine*.

Please be assured that when it comes to your monthly publication, it is business as usual, and in the months ahead we are excited to be bringing you coverage of Earth's constant journey on its orbit round the Sun and the changing views of the night sky this brings.

This month we celebrate the 30th anniversary of the Hubble Space Telescope's launch with a special 18-page section. Jenny Winder's feature on page 30 tells the thrilling story of how the great observatory's faulty mirror was repaired in space and looks at the remarkable astronomical discoveries this enabled. On page 38 we look ahead to Hubble's successor, the James Webb Space Telescope, and on pages 26 and 40 there are galleries of Hubble's stunning images which brought the majesty of space to millions on Earth.

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Stay safe and clear skies everyone!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 21 May.

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Sky at Night – lots of ways to enjoy the night sky...



Television

Find out what *The Sky at Night* team have been exploring in recent and past episodes on page 17



Online

Visit our website for competitions, astrophoto galleries, observing guides and more



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Podcasts

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PULLOUT

New to astronomy?

To get started, check out our guides and glossary at www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Shaoni Bhattacharya



Journalist

"The JWST (James Webb Space

Telescope) will let astronomers peer back in time to the early Universe – I'm inspired by what it might find." **Shaoni looks forward to a new era of observing, [page 38](#)**

Neil Norman

Comet hunter



"With it being some 20 years since the last great

comet graced our skies, it has been a great honour to relive the memories of these comets of the past." **Neil highlights the greatest comets of recent times, [page 64](#)**

Jenny Winder

Author and journalist



"Seeing the first faulty images from Hubble, I

thought of all the people who had worked on it. Writing about how it's now exceeded all expectations is my testament to them." **Jenny celebrates Hubble at 30, [page 30](#)**

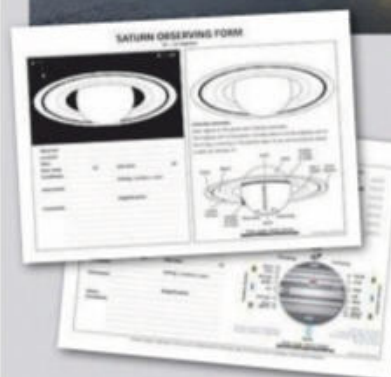
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MAY HIGHLIGHTS

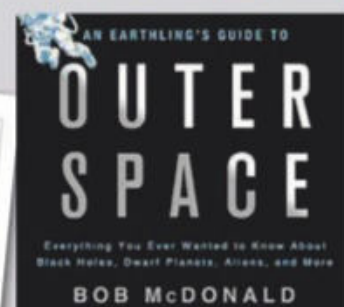
Exploring the oceans of icy moons

NASA scientist Kevin Peter Hand reveals the latest in the search for signs of life within our Solar System.



Download observing guides and charts

Access planet observing forms, binocular and deep-sky tours and our guide to Southern Hemisphere stargazing.



An Earthling's Guide to Outer Space

Listen to two chapters from an audiobook answering some of the biggest questions in space and astronomy.

The Virtual Planetarium



Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

Superstar FACTORY

Cosmic clouds of glowing gas may hold the secrets to star formation

HUBBLE SPACE TELESCOPE, 18 MARCH 2020

Its rather dull name, LHA 120-N 150, belies the beauty of this bright pink crucible of star formation sitting on the edge of the Tarantula Nebula.

A super-concentrated area of massive stars, called a super star cluster, it lies relatively near to us at 160,000 lightyears away in the Large Magellanic Cloud. With little obscuring cosmic dust in between, the region is readily viewable from Earth and so is now a favourite target for astronomers hoping to understand how stars, particularly massive stars, are born.

One theory is that they form within and are then ejected from clusters in the glowing clouds of gas and dust. Already, though, this would appear to be contradicted by observations that many of the stars studied seem to form in isolation.

What makes the task even harder is that although the region potentially hosts dozens of 'stars' to study, young massive stars can appear similar to dense clumps of dust.

MORE ONLINE

A gallery of these and more stunning space images





△ Mystery asymmetry

HUBBLE SPACE TELESCOPE, 23 MARCH 2020

Instead of the conventional two or more arms, unusual barred spiral galaxy NGC 4618 has just one curling out from its centre. Found 21 million lightyears away in Canes Venatici, its asymmetry may come from a long-past gravitational tussle with nearby neighbour NGC 4625. If so, it's hard to know which came off worst, as both combatants lost an arm in the galactic face-off. Lop-sided, single-armed galaxies like this are sometimes called Magellanic spirals because of their resemblance to the Magellanic Clouds.



△ Face of a killer?

OSIRIS-REX SPACECRAFT, 19 MARCH 2020

This mosaic, compiled by NASA from 2,155 images taken by the OSIRIS-REx spacecraft last spring, reveals the surface of the asteroid Bennu as never seen before. OSIRIS-REx passed just 3–5km above the asteroid's surface to capture these detailed pictures. Bennu, dubbed a Doomsday asteroid by some, is on both NASA's and ESA's risk lists, with a 1-in-2,700 chance of striking Earth in the late 22nd century.



△ What Apollo 13 saw

LUNAR RECONNAISSANCE ORBITER, 24 FEBRUARY 2020

It was a cruel twist that, their mission aborted, the only way Apollo 13's crew could steer for home was to 'slingshot' their stricken craft around the far side of the Moon, passing tantalisingly close to the lunar surface on which they would never land. Lovell, Swigert and Haise could only look down and take photos in those 25 minutes of radio silence as they passed from light, to dark, to light again. Their view in those moments of isolation has now been digitally recreated in crisp 4K from detailed images taken by the robotic Lunar Reconnaissance Orbiter. View the full film here: nasa.gov/multimedia/videogallery/index.html



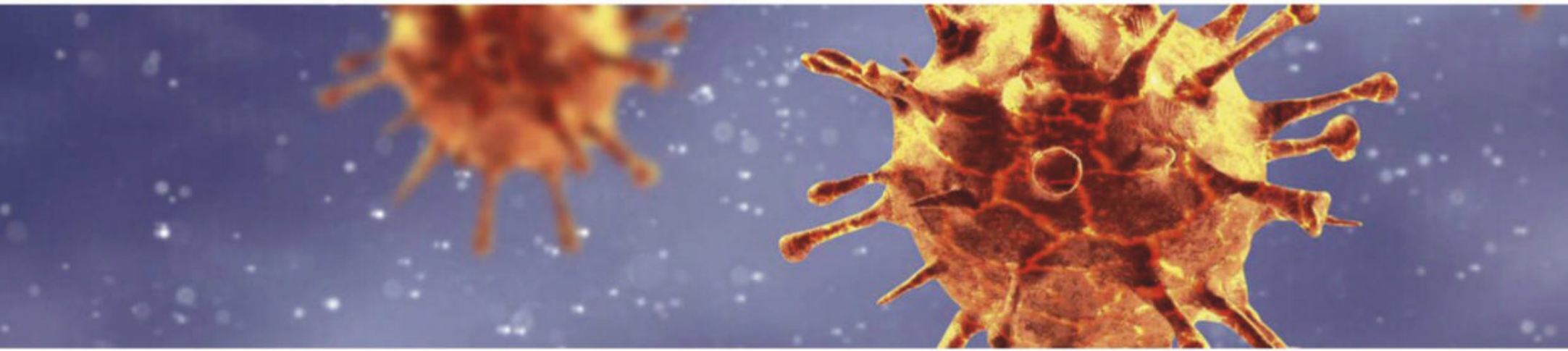
△ Peace on Earth?

INTERNATIONAL SPACE STATION, 20 MARCH 2020

The lights of Europe and Asia glint prettily beneath a star-packed sky in this image taken from the International Space Station in March. The three crew members on board, safely isolated from COVID-19, orbit 400km above Earth, their home a football pitch-sized craft travelling at 28,000km/h. As work at space agencies around the globe is put on pause in the face of the pandemic, the station's international crew continue their schedule of maintenance tasks and experiments. They still see 16 sunrises and sunsets every day: the world keeps turning.

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN



Space sector feels effects of pandemic

Missions and research have been put on hold while the world fights the virus



PANORAMA IMAGES/STOCK/GETTY IMAGES, NASA X 2, UGO/CALTECH/MIT/JEFF KISSEL

Over the last few months, the COVID-19 virus has affected every facet of human endeavour. Space exploration and industry has been no exception. With researchers unable to travel to their workrooms and telescopes, dozens of projects have been delayed while others have found ingenious ways to carry on exploring our Universe despite the difficulties.

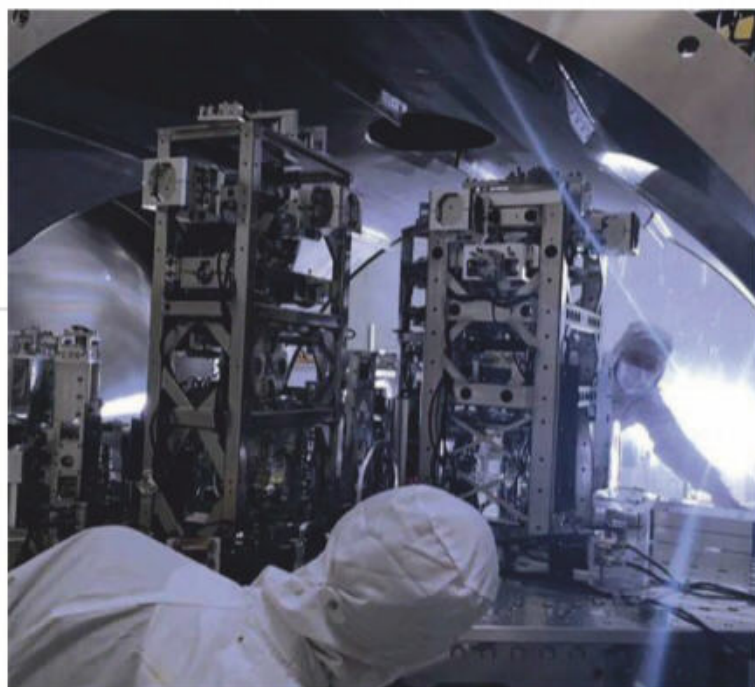
Like many organisations, NASA has ordered all non-essential personnel to work from home to help combat the virus's spread, but is also making a more direct attack on the pandemic by helping to build and

▲ **Still on track:** it's hoped that the launch of NASA's Mars rover Perseverance will go ahead in July 2020

improve the ventilators hospitals desperately need, while also opening up supercomputing resources to researchers working on COVID-19.

"Where hands-on work is required, it's difficult ...to comply with CDC (Centers for Disease Control and Prevention) guidelines while processing spaceflight hardware, and where we can't safely do that we'll have to suspend work and focus on the mission critical activities," says Jim Bridenstine, NASA's administrator.

Several high-profile missions have already fallen foul of the restrictions imposed in the wake of the outbreak.



◀ On hold: LIGO, the Laser Interferometer Gravitational-Wave Observatory, has suspended upgrade work



Astronaut Chris Cassidy (right) is scheduled to visit the ISS after undergoing an extended quarantine

Work on the James Webb Space Telescope as well as the Orion crew module and the heavy-lift rocket, the Space Launch System, has been put on hold. All three projects have suffered launch date slips in the past, and now a new delay seems almost inevitable.

Making priorities

Meanwhile, the European Space Agency (ESA) has put many of its missions into hibernation – including the Solar Orbiter which only launched in February – to reduce the number of staff needed at operational facilities in Europe. They have also postponed the Rosalind Franklin Mars rover until 2022. Experts from across Europe were attempting to fix issues with the landing system before its July launch, but are now unable to work on the rover. “People from different places of industry in Russia, in Italy and France cannot move easily, as in the past,” says Jan Wörner, ESA’s director general. “So there is also an impact. I would not like to say the coronavirus is the one and only reason – but... it has an impact on the mission, yes.”

Two other Martian rovers currently look set to meet their launch dates despite the virus. NASA’s Perseverance (formerly known as Mars 2020) is being given priority over other missions due to the short launch window to the Red Planet. Meanwhile, the

Chinese National Space Administration has continued work on its own rover – despite being the nation longest affected – by using protective gear and wide-scale disinfection.

Another mission which looks likely to go ahead is the latest expedition to the International Space Station. The crew will undergo their usual two-week quarantine before launch, though this will be stricter than normal.

“I will have no launch guests at the Baikonur Cosmodrome,” says one of the astronauts, Chris Cassidy. “It’ll be completely quiet. There won’t be anybody there. We’ll just kind of walk out.”

Back on Earth, observatories around the world have either reduced their staff or shut down entirely. The Atacama Large Millimeter/Submillimeter Array took its last scientific observation on 19 March, while the LIGO gravitational wave observatory cut off its third observing run early and is suspending all work on the planned upgrades to the detector.

The American Astronomical Society’s (AAS) meeting planned for this June, which usually gathers thousands of astronomers from all over the world, has now switched to a fully remote and virtual conference – a move the AAS had already been investigating as a way to lower its carbon footprint.

It’s not just professional astronomers who have been affected. To help protect their members, many amateur societies in the UK cancelled their regular meetings several weeks before the government ban on large gatherings. The outbreak also meant several amateur astronomy fairs were postponed. Among them was the world’s largest, the Northeast Astronomy Forum, although show goers didn’t completely miss out as the organisers ran a virtual fair on 4 April, featuring live streamed talks and gear demonstrations, and the actual show has been rescheduled for 12-13 September.

Though the virus has put many projects on pause, it has not stopped them entirely. The scientific and commercial space communities are currently prioritising the health and well-being of their staff, so that when the pandemic subsides they will be fit enough to continue their work in exploring the cosmos.

All information was accurate at time of going to press, but changes may have occurred due to the evolving nature of the pandemic. See skyatnightmagazine.com for the latest news.



Comment

by Chris Lintott

All over the world, giant telescopes which normally scan the sky are standing idle to protect staff. Though clearly the right decision, I initially found it hard not to feel the loss.

But then I looked up at a night sky, mercifully clear during the first week of full lockdown and saw bright Venus, and Betelgeuse returning to normal brightness, and, passing by, a waxing crescent Moon. The act of observing the Universe reminded me that it will still be there waiting for us when we can all look up once more.

Walt Whitman wrote a poem about relieving the discombobulation – about looking ‘up in perfect silence at the stars’, after hearing from a ‘learn’d astronomer’. I hope you all get a chance to do that and it helps bring some calm.

Chris Lintott
co-presents
The Sky at Night

NEWS IN BRIEF

BULLETIN

Quasars turn off their galaxies

The winds of black holes can be so strong they stop stars forming



Are quasars stopping star production in its tracks?

radiation, heating the surrounding gas and dust to enormous temperatures. If the heat is intense enough, the surrounding gas accelerates until it's travelling a few per cent of the speed of light.

"The amount of mechanical energy that these outflows carry is up to several hundred times higher than the luminosity of the entire Milky Way Galaxy," says Nahum Arav from Virginia Tech, who led the study.

This wave of material slams into the galaxy's dust lanes, stopping them from producing stars, providing a potential answer to the long-standing mystery of what shuts off stellar birth in massive galaxies.

<https://hubblesite.org>

A recent examination of Hubble observations has found that some quasars are so energetic they 'turn off' their galaxies, stopping

them from producing stars.

Quasars are supermassive black holes which have matter raining down onto them. This creates huge amounts of

Earth finds and loses new moon

Astronomers briefly discovered we had a new mini-moon, only for Earth to lose it a few weeks later. The moon, 2020 CD3, was first discovered by the Catalina Sky Survey on 15 February, though it could have been orbiting our planet for as long as three years. Alas, it was only discovered just as it was leaving, drifting into solar orbit around 7 March.

Human test for Crew Dragon

The first human test flight of SpaceX's Crew Dragon spacecraft is due to fly to the ISS as soon as the end of May. The test will carry two NASA astronauts on a brief sojourn to the ISS. If successful, NASA will begin using the Crew Dragon full-time to ferry astronauts to and from the station.

Jupiter's thick Red Spot

Jupiter's Great Red Spot may be shrinking in diameter, but it's still as thick as ever. Recent computer simulations – which recreated the giant storm's evolution over many decades – found that no matter the fluctuations in its size, the Red Spot's depth through the atmosphere remains constant.

Distant binary stars have wonky planets

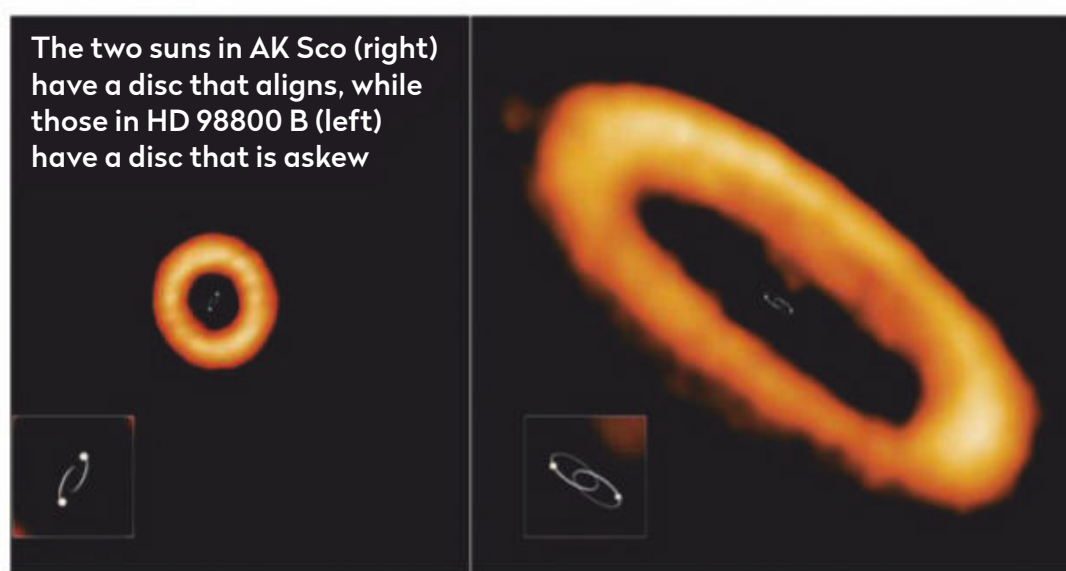
A new study investigating the strange orbits of so-called 'Tatooine' worlds – those orbiting a binary pair of stars, with two suns in their skies – has revealed the further apart a pair is, the wonkier their planets are.

The study used the Atacama Large Millimeter/Submillimeter array (ALMA) to look at circumbinary discs, the planet-forming rings of dust around young binaries.

"With our study, we wanted to learn more about the typical geometries of circumbinary discs," says Ian Czekala from the University of California at Berkeley, who took part in the study. "The high-resolution ALMA data was critical for studying some of the smallest and faintest circumbinary discs yet."

This found the discs around stars orbiting each other are quickly aligned with the plane of the stars. Pairs with longer orbital times

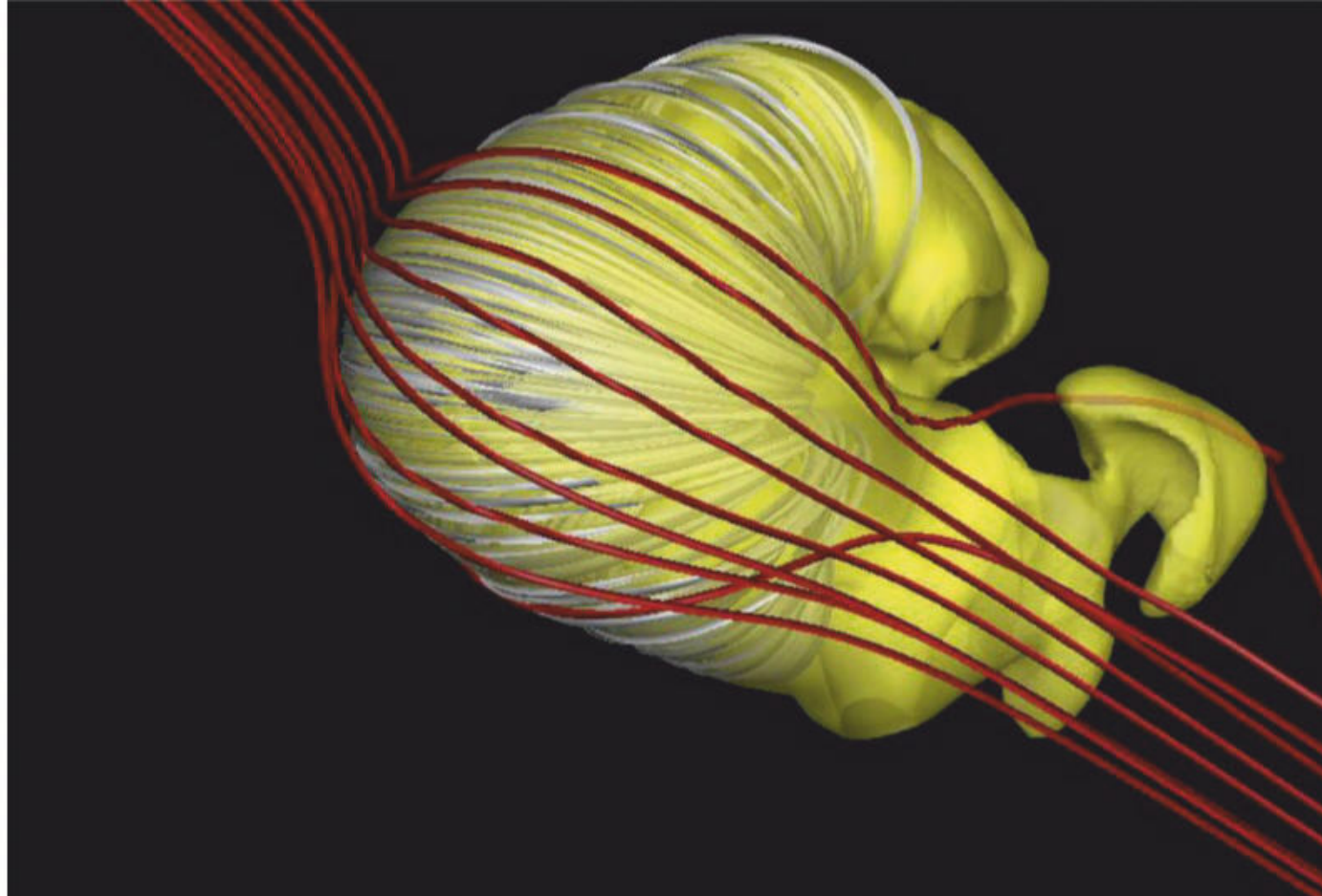
The two suns in AK Sco (right) have a disc that aligns, while those in HD 98800 B (left) have a disc that is askew



– usually meaning they're further apart – have more off-kilter discs. Testing whether this misalignment extends to the planets created is difficult, however. Previous exoplanet surveys such as Kepler have struggled to observe planets around wide binaries, meaning there could be an entirely new population of Tatooine worlds waiting to be discovered.

www.almaobservatory.org

NEWS IN BRIEF



▲ Is this the shape of the heliosphere – the force field that protects our Solar System from cosmic rays?

Debate over solar bubble's shape deepens

Is the heliosphere shaped like a bulging croissant?

Space scientists have been arguing over whether the heliosphere – the bubble created by the solar wind – is shaped like a comet, a croissant or a ball for several years. Now, new simulations suggest the real shape could actually be a hybrid.

Astronomers have long assumed the heliosphere is swept back by the Sun's motion through the Galaxy, forming a comet-like tail. However, when Voyager 1 passed through the outer Solar System in 2015, its readings

suggested the 'comet' is actually a crescent with two tails. Then, scientists using Cassini measurements suggested it was spherical.

The new paper by astronomers from Harvard and the University of Michigan combines the two spacecraft measurements to create a new view of the heliosphere as a bulging croissant, halfway between crescent and sphere. The view is controversial though, and debate over the true shape of the Solar System continues.

www.bu.edu/csp

100 minor planets revealed

Astronomers have serendipitously discovered over 100 new minor planets beyond the orbit of Neptune. The worlds, detailed in a new paper, were found in images initially taken to investigate dark energy, but as the fields were wide and deep, they were also ideal for tracking down minor planets in the outer Solar System.

Star forming regions mapped

The most detailed large-scale map ever made of Orion A, the Aquila Rift and M17 – three regions which are rapidly forming massive stars – has been created by the Star Formation Project. The map, produced using Japan's Nobeyama 45m Radio Telescope, has a resolution of 3,200 AU, around 60 times the Solar System's size.

SETI search takes a break

One of the longest-running citizen-science projects, *seti@home* – which uses the home computers of around 100,000 volunteers to look for signs of a radio transmission from aliens – is taking a break. It sent out its last data to participants on 31 March. The research team will now take time to examine its findings.

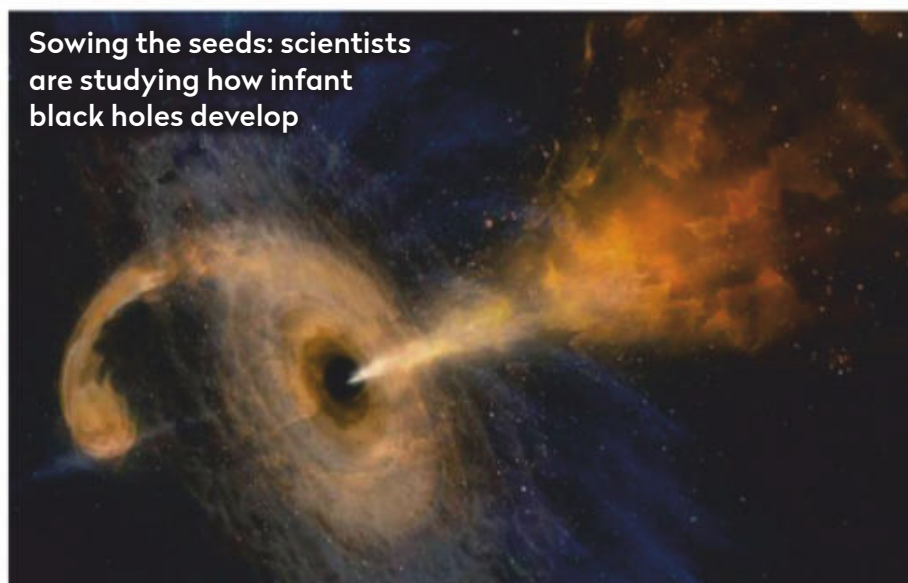
Black holes are big babies

Astronomers have discovered that infant supermassive black holes are much larger than expected, potentially explaining their rapid growth. The giant black holes have been spotted in the Universe just 800 million years after the Big Bang, but astronomers have struggled to explain how they reached their enormous size that quickly.

A new study could potentially hold the answer, by looking not at the growth of the black hole itself, but at how its initial 'seed' formed. These infant black holes formed in the gas-rich centres of early galaxies, where many extremely large stars formed.

"The biggest stars live a short time and very quickly evolve into stellar black holes,

Sowing the seeds: scientists are studying how infant black holes develop



as large as several scores of solar masses. They are small, but many form in these galaxies," says Lumen Boco from Scuola Internazionale Superiore di Studi Avanzati, who led the study.

The study showed these

black holes then merge together, forming a seed as large as 100,000 solar masses – much larger than first thought and giving black holes the early boost they need to grow to the sizes we see today.

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CUTTING EDGE



After a colossal impact, was debris from Mercury blown away by the solar wind?

Mercury blown away by the Sun

The planet's outer layers could have been stripped by a huge collision and solar wind

The rocky inner planets of the Solar System – Earth, Venus and Mars – all have about the same mixture of iron and silicate rock in their make-up, and so are roughly the same bulk density. But Mercury is something of an oddity.

The innermost world is much denser than you would expect as it has a huge iron core that makes up over 80 per cent of the planet's diameter (for comparison, Earth's is closer to 10 per cent).

The leading explanation for this is that Mercury did form similarly to the other rocky planets, following the same primordial recipe, and was once about the same size of Mars. But shortly after its formation, Mercury was struck by a colossal impact. This hurled away most of its outer mantle, leaving behind the iron core to make up a much greater fraction of the final planet.

Making an impact

This giant impact hypothesis makes a lot of sense on the face of it, and indeed giant impacts during the Solar System's early years are thought to be behind the formation of Earth's Moon and the tilt of Uranus.

One major problem with this idea is that much of the vaporised material blasted off Mercury by a giant impact would condense into solid spherules. These marble-sized pebbles would remain in nearby orbits to Mercury around the Sun, and so simply re-accrete back onto the planet over a few tens of millions of years. So the overall iron-silicate ratio of Mercury wouldn't end up changing much at all.

The mystery, then, is if a giant impact did strip away Mercury's silicate outer layer, what stopped it all re-accreting again? Christopher Spalding and Fred Adams, the authors of this month's paper, think they have the answer.

The key, they say, is to consider the solar wind; a flow of charged particles racing out from the Sun at hundreds of kilometres a second. While this solar wind is very diffuse, it does induce a drag force on orbiting bodies. And, as Spalding and Adams point out, the primordial Sun during the time of these giant impacts, around 4.5 billion years ago, would have possessed a stronger

"If a giant impact did strip away Mercury's silicate outer layer, what stopped it all re-accreting again?"

magnetic field, faster rotation, and a stronger wind. In fact, the solar wind streaming off the young Sun was likely to be 10 to 100 times more intense than today.

With such a strong flow of solar wind, the material blasted off Mercury would experience a significant drag and be readily cleared away from the planet's orbit. Spalding and Adams calculate that over

a timescale of less than a million years, the ejecta would have migrated away from Mercury. This is much quicker than the material could re-accrete back onto the planet, and so this solar wind sweeping processes provides an explanation for how Mercury could have been stripped of its silicate mantle by a giant impact, without then collecting it all back up again.

It turns out a rampaging nameless protoplanet could have created Mercury as the cannonball world it is today by conspiring with a more intense solar wind.



Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *The solar wind prevents re-accretion of debris after Mercury's giant impact* by Christopher Spalding and Fred C Adams. Read it online at <https://arxiv.org/abs/2002.07847>

Under a Starlink sky

How will SpaceX's plans to launch thousands of satellites into low-Earth orbit affect views of the night sky?

By day, Jonathan McDowell is an X-ray astronomer, part of the team who keep the Chandra space telescope running and productive, staring at some of the distant Universe's most energetic phenomena. In his spare time, he keeps track of objects much closer to home, cataloguing the population of satellites that clutter low Earth orbit.

He's therefore the right person to weigh in on SpaceX's rapidly growing constellation of 'Starlink' satellites, and in a new paper he does just that. Starlink's initial plans were for just over 1,500 satellites, but SpaceX has permission to launch as many as 12,000, and maybe many times that. Even with 1,500 in orbit, McDowell explains the effect will be dramatic.

That might seem surprising. There are, after all, nearly 5,000 satellites already in orbit, so the initial Starlink deployment accounts for only a small addition. But to be bright – visible with the naked eye – you need a satellite to be both large and in low Earth orbit, and there just aren't that many satellites for which this is true. In higher orbits debris and defunct satellites can last a long time, but anything large that orbits under 600km above the surface will burn up in the atmosphere before too long.

Changing views

Starlink satellites – which are both large and low – already account for the majority of active large satellites in lower orbits, and a large proportion of the satellites that are visible to the naked eye. If we're heading for even only 1,500 Starlinks in the near future, four in every five bright satellites will belong to the constellation. I've already spotted some of them myself, and as the paper makes clear, they will be visible for long stretches of the night.

Using real observations from a network of volunteer observers (satobs.org), the paper builds a model for how the constellation of satellites will look when



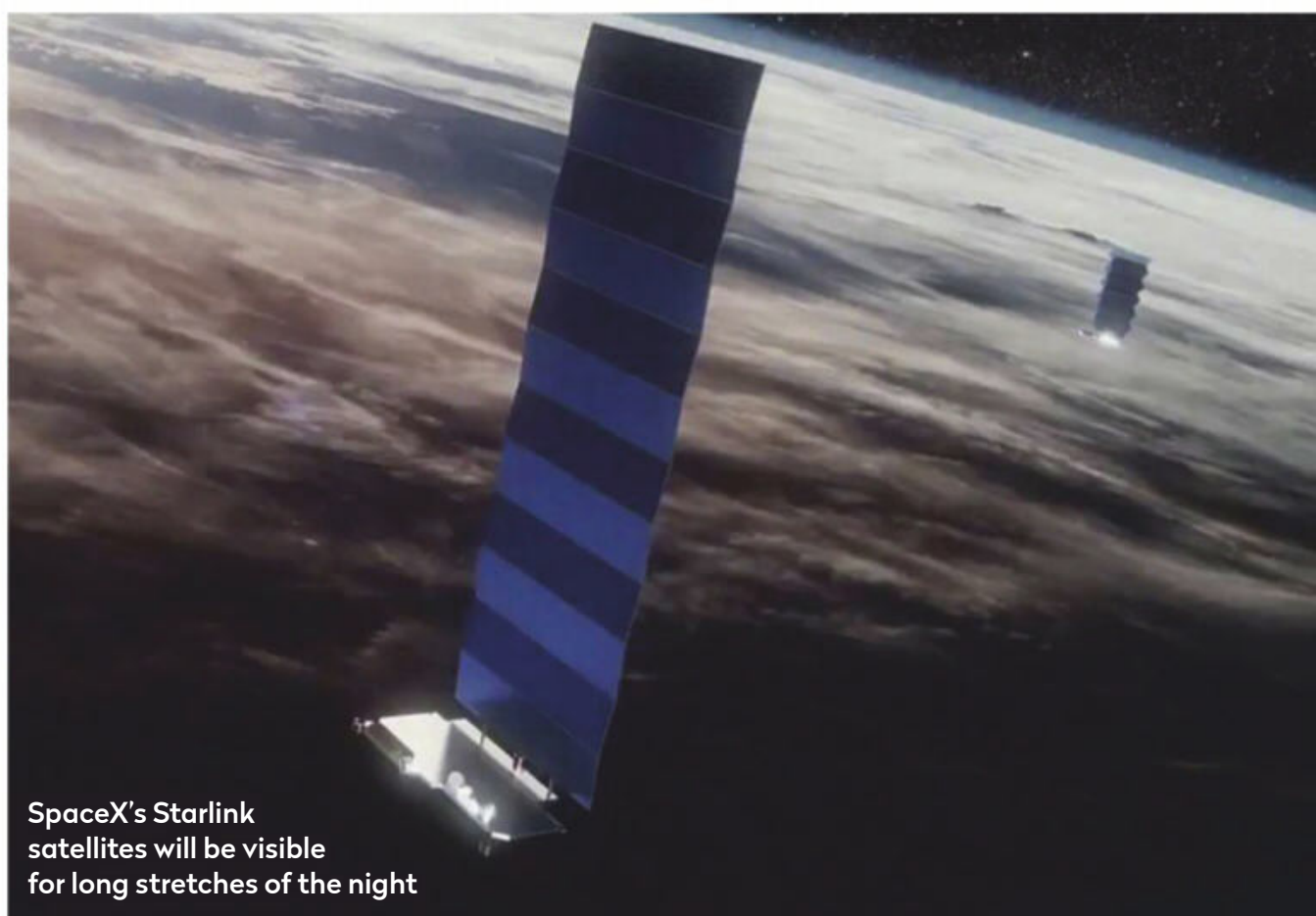
Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

"Starlink satellites are both large and low, and already account for the majority of active large satellites in low Earth orbit"

deployed. They're typically between magnitudes 4 and 6 – in naked-eye visibility range from a dark site. From almost any observatory location, hundreds are above the horizon at all times and, during the summer months, they will be bright throughout the night. During the winter, from most locations, there are hours of respite either side of midnight, but much of the night will still be Starlink-streaked.

For the biggest surveys astronomers are planning, which use wide-field cameras to cover much of the sky, it seems possible that every image taken will have a satellite streak due to a Starlink satellite. For casual observers, who may care more about the view near the horizon, or those hunting near-Earth asteroids by scanning the twilight sky, the situation is worse.

Can anything be done? SpaceX themselves have experimented with changing the design of the spacecraft, and one special, darkened satellite is currently in orbit. Initial observations suggest that the changes might work, taking the satellite out of naked-eye visibility, but more careful monitoring is needed. The warning from this paper is that our night sky might be changing, and fast – and if so it will never be the same again.



SpaceX's Starlink satellites will be visible for long stretches of the night

Chris Lintott was reading... *The Low-Earth Orbit Satellite Population and Impacts of the SpaceX Starlink Constellation* by Johnathan C McDowell.
Read it online at: <https://planet4589.org/space/papers/starlink20.pdf>

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



As *The Sky at Night* reaches its milestone 800th episode, producer **Michael Lachmann** gives an insight into life behind the scenes

What's it like working on one of the world's longest running series? Well, for one thing it's not glamorous. *The Sky at Night* is an astronomy show after all – it's only right that we have spent countless nights standing on hilltops in the middle of nowhere waiting for the rain to stop and the clouds to clear.

But it's not all rainy nights in Leicestershire.

Regular viewers will know that the programme's secret is not a vast budget or endless resources. In fact *The Sky at Night* is one of the best value programmes on television. On most productions there is an army of staff – producers, directors, camera operators and sound recordists – sometimes even catering. Not on *The Sky at Night*: it has a full-time staff of just three people, who do everything – from writing the scripts and organising the logistics to operating the cameras and recording the sound. So apologies if the occasional wobbly shot or crackly interview makes it through!

Even so, working on *The Sky at Night* is a tremendous privilege because the good name and history of the programme has given us access to some of the most exciting places and events in astronomy.



Just recently, we sent a team to the launch of the Solar Orbiter mission. We have been to the mission control rooms of the Juno and New Horizons spacecraft. We have been granted access to some of the world's largest telescopes – like the Gran Telescopio Canarias on La Palma – and observing time on the Swift Space Telescope.

I think the reason for this generosity is simple. Generations of astronomers – both amateur and professional – have grown up watching *The Sky at Night*. And now – happily – they are prepared to go to

▲ In the action: ahead of the world's press, *The Sky at Night*'s Chris Lintott lands an interview with project scientist Matt Taylor at the climax of the Rosetta mission in September 2016

◀ Moon talk: Maggie Aderin-Pocock talks with the first British astronaut, Helen Sharman, on the 50th anniversary of the Apollo 11 Moon landing



Michael Lachmann
is a series producer
for *The Sky at Night*

extraordinary lengths to be part of the programme and share their work with our audience.

One of my favourite moments was in 2016, at the end of the Rosetta mission. Journalists from all over the world had gathered in Darmstadt, Germany to observe the spacecraft's final few orbits before it crashed onto Comet 67P. The key interview everyone wanted was with project scientist Matt Taylor, the project scientist.

But for the mission's crucial final moments of the mission he turned down all offers and sat chatting with Chris Lintott in front of our cameras; while the rest of the world's media stood back and watched. It wasn't just that this was a major coup for a small programme

like *The Sky at Night*. It also wasn't your average interview. The conversation was open and emotional – there were tears and hugs as the final telemetry from the spacecraft was received. It was a human insight into the workings of a mission that you rarely get to see.

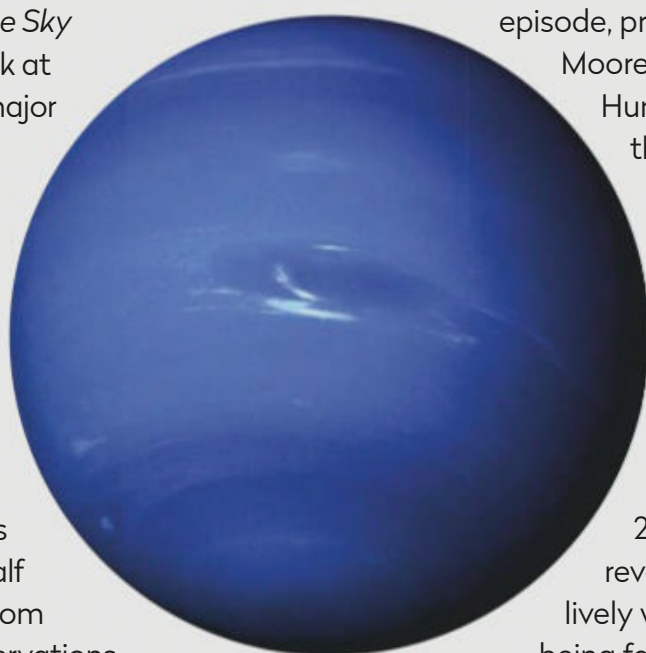
And that is what's so special about working on *The Sky at Night*. Over its 60-plus years it has built up a bond with its audience that means it has become a trusted part of the astronomical community. Trusted to tell the most important stories in a way that will appeal to newcomers and experts alike. And the night sky is huge. With only 800 episodes completed so far, there is still plenty more to cover. 🌌

Looking back: The Sky at Night

31 May 1981

On 31 May 1981, *The Sky at Night* took a look at the most distant major planet of our Solar System, Neptune. Though the gas giant had been discovered over a century before in 1846, it had remained something of an enigma. Neptune is some four and a half billion kilometres from Earth, making observations challenging. Even by 1981 little was known about the planet, though astronomers had managed to measure the planet's rotation – once every 16 hours – and discovered at least one large moon, named Triton.

This would soon change, however, as interplanetary spacecraft Voyager 2 was due to fly past the planet in 1989. On the



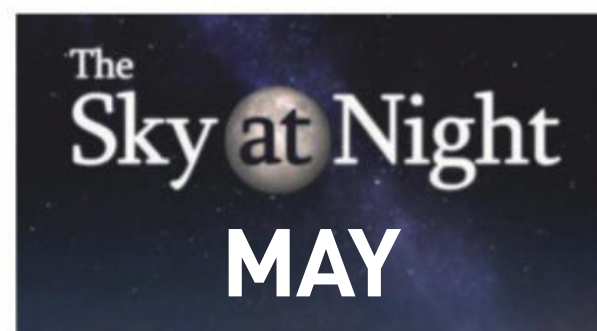
▲ **Blue wonder: Neptune proved to be a lively world with extremely fast winds**

reached over 2,000 km/h.

Moore and Hunt teamed up over Neptune once again in 1994, when the pair wrote a summary of all we knew about the planet up until that point, called *Atlas of Neptune*.



episode, presenter Patrick Moore spoke with Garry Hunt, a member of the spacecraft's imaging team, about what the future flyby hoped to achieve. When Voyager 2 eventually flew past the planet on 25 August 1989, it revealed a surprisingly lively world. Despite being far away from the heat of the Sun, the planet was home to the fastest winds in the known Solar System, which



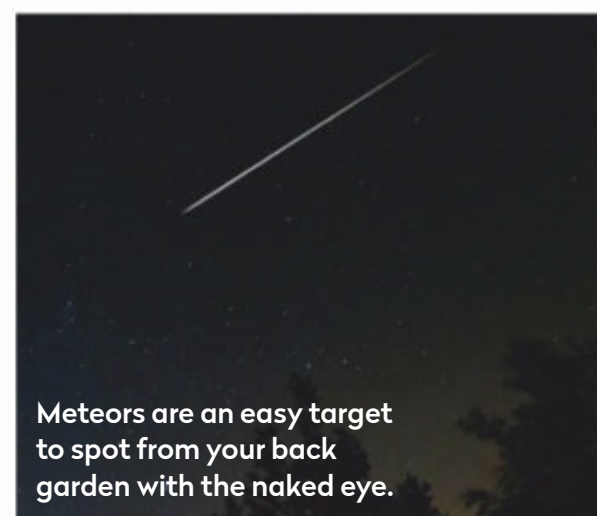
800th episode

The Sky at Night marks its 800th episode with a 'back to basics' lesson in practical astronomy. Topics include the dimming of Betelgeuse, how to observe meteor showers and spotting bright Venus. Plus, there's a look back at Patrick Moore's stargazing techniques; a beginner's guide to the Messier catalogue of celestial targets; the latest from the Mars InSight mission; and how to get started in astrophotography.

BBC Four, 10 May, 10pm (first repeat

BBC Four, 14 May, 7.30pm)

Check www.bbc.co.uk/skyatnight for subsequent repeat times



Meteors are an easy target to spot from your back garden with the naked eye.

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at inbox@skyatnightmagazine.com

MESSAGE
OF THE
MONTH

This month's top prize:
four Philip's books



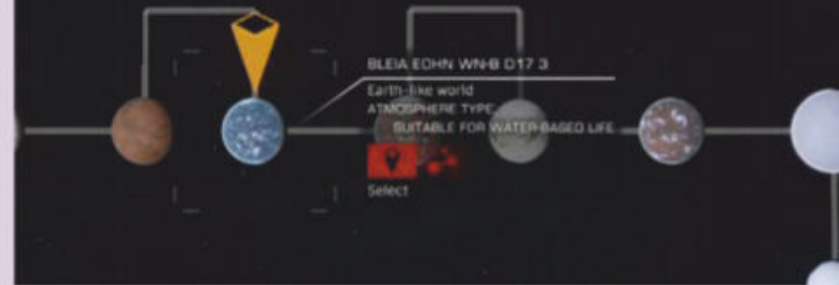
PHILIP'S The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2020 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

The name of the game

Reading *Field of View* in the April issue about the International Astronomical Union (IAU) naming convention for stars and their planets, I was reminded of the online space exploration, trading and combat game *Elite Dangerous* and its planetary naming system, which, to me, seems more logical than the one the IAU uses. The creators put all known, catalogued stars into the game at their correct distances, brightnesses and spectral types and also added exoplanets. The naming system in *Elite* doesn't involve renaming a star with an 'a' and then adding b, c, d, etc for its planets and is, I would suggest, more consistent than the IAU one. It uses capital letters for stars in close association and differentiates planets from stars with numbers, and exomoons from planets with a lower-case letter. For non-catalogued stars the game's developers generated a naming system that organises the stars in sectors, eg, 'PRAEA EUQ SV-G C26-1', for a star in the 'PRAEA EUQ' sector. It also copes with describing a planet that might orbit all or part of a group of stars,

Have the creators of the game *Elite Dangerous* solved the problem of naming exoplanets?



eg, 'M7 SECTOR WP-W C2-13 BCDE 2', the second planet orbiting four of the stars of a five-star cluster. Finally, if, like me, you and the readers are frustrated space explorers, then *Elite Dangerous* is the next best thing.

Raymond D Wright, Devizes, Wilts

A fascinating observation, Raymond. The challenge with planetary naming is to come up with a system that can cope with our growing knowledge of exoplanets, as well as their remarkable variability. – **Ed.**

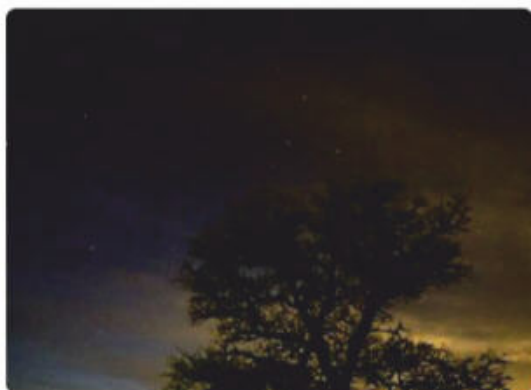
Tweets



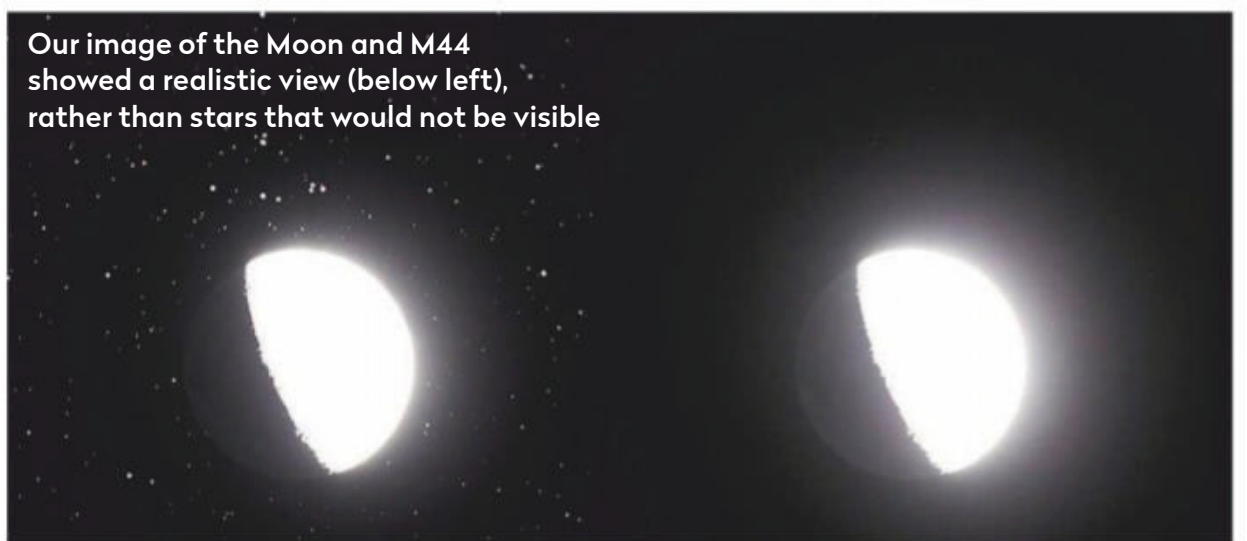
Paul Tanner Photo

@ptannerpix • Mar 24

Cassiopeia above a tree near #rafshawbury last night. @MetOShawbury @BBCShropshire @skyatnightmag @shropastrosoc @ClareAshford @ThePhotoHour @TheBearSteps #SocialDistancing



Our image of the Moon and M44 showed a realistic view (below left), rather than stars that would not be visible



Picture perfect?

I noticed that the photograph of the conjunction between the Moon and M44 in the March issue Sky Guide ('The Big Three', page 46) only seems to show half of the captioned subjects: the Moon. In

the printed version the Moon is big and bright, but there's not a star in sight. I have noticed this several times before with other subjects. It would be good to ensure everything appears in such images, rather than reproducing the view that

those of us living under bright city skies would see!

Peter Shirley, West Bromwich

In the magazine we strive to show things as they will appear or use real astrophotos of subjects, but when a rare event hasn't happened yet we will create a simulation. In this case the image in the magazine does show stars but they are small and tricky to see well, which accurately reflects the view you'd get visually or photographically of the scene with its huge dynamic range. – **Ed**

Scope view?



I enjoyed seeing Paul Lytte's picture of the 'Great Red Spot' on his living room door in the

April issue ('Interactive', page 20). Similarly, I'm reminded to keep my reflecting telescope collimated when I look at my bathroom door!

Sean Clarke, Cuddington, Bucks



▲ **Light in darkness:** the diamond ring effect at the Indonesian total solar eclipse on 9 March 2016, taken by Michael Knowles

Rays of hope

Embarking into my local town last week for a few essential items was a reality check. Seeing from my television screen the effects of our fight against COVID-19 is one thing, but its impact in the town centre was surreal. Practically deserted, it reminded me of the sci-fi film *The Day the Earth Stood Still*. But the virus is a challenge from the inner universe, not from outer space, and these times have brought the best out of us all in pulling together as one. Our frontline services are a beacon of light, and I would like to offer this thought for all the people involved directly in the response: whatever unprecedented situations may eclipse us, rays of light will endure to prevail (see picture, above).

Michael Knowles, Mansfield ▶



ON FACEBOOK

WE ASKED: How do longer days and shorter nights affect your observing?

Mark Arnold Fewer multi-clothing layers! I tend to focus on the Moon and planets in the summer as well as a bit of galaxy or nebula hunting.

Mick Cassidy I have a Dob so it's a 1-minute set up. Scope out all year round but for sure it gets more EP use in the darker months.

David Heflin I don't like it – it drastically reduces my scope time.

Michel Huisman It's an opportunity for daytime Sun viewing, with a proper Sun filter of course.

Dale Jones Keep getting the scope out – Saturn and Jupiter.

Tony Moss I just stay up later and keep warmer.

Colin Wilson Late nights!

Steve Komarek I only do astrophotography and now I've completed my own design for a fully automated roll on/roll off shed I can set up a sequence in NINA, go to bed and when my sequence finishes at 4am for example, the scope will park and the shed will close up. Happy days.

SCOPE DOCTOR



Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I'm a new stargazer. I currently own a set of binoculars that let me view the Moon's craters, but I'd like a telescope to start looking at the planets. What can you recommend for a mobility limited pensioner?

DEREK GUY

Close up views of the Moon and planets require a telescope with a long focal length and for compactness and ease of setting up, a Maksutov Cassegrain on an altazimuth Go-To mount is hard to beat. A Maksutov-Cassegrain scope will also open up observations of galaxies, open star clusters, globular clusters, planetary nebulae and many other deep-sky objects.

Suitable instruments include the Sky-Watcher SkyMax 127, SynScan AZ Go-To or the Celestron NexStar 127SLT Computerised Telescope.

Small altazimuth Go-To mounts like those above are light, simple to assemble and make for quick and easy location of objects, but they can be prone to vibration when adjusting the focus. They have internal battery compartments, but an external 'PowerTank' will help to provide plenty of power.

If you would prefer a manually operated mount then the Sky-Watcher SkyMax-127 AZ5 Deluxe would also be suitable and has the advantage of a very stable mount.



▲ **Light and easy:** the Celestron Nexstar 127SLT

Steve's top tip

Do I need to let my telescope cool down before observing?

When you take your telescope outside for an observing session, the column of air within the telescope generates a micro version of atmospheric disturbance, in the form of tube currents, as it tries to reach temperature equilibrium with the air outside. These tube currents distort and diffract the light from celestial objects, robbing your view of fine detail and giving stars distorted and smeared shapes.

To stop this from happening, it is important to set up your telescope outside some time before you intend to start observing to allow it to cool down to the temperature of the surrounding air.

Steve Richards is a keen astro imager and an astronomy equipment expert

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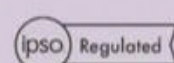
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▲ **Destined for NASA: the artwork for our April cover was created by Bruce Emmett**

Apollo 13 accolade

► I was the Apollo 13 Spacecraft Warning System Engineer and while Lovell, Haise and Swigert were on board, I was watching over their shoulders throughout the mission from the Mission Evaluation Room at Johnson Space Center in Houston. I was the virtual crew member responsible for their caution and warning system, sounding the master alarm siren in their ears and activating the red master alarm light, leading them to say, "Houston, we've had a problem." What a great job of artwork the cover of the April issue is! Among those I've seen in my past half century of enjoying them while working at NASA, this is among the very best – and that includes the one by

astronaut Al Bean. I noticed that the lander's legs are not deployed, a common misconception in depictions of the explosion. I'll frame the cover in my NASA office – it's that good. Please give my compliments to the artist.

Jerry Woodfill, Houston, Texas, US

Jerry Woodfill was interviewed by Elizabeth Pearson for the Q&A in April's issue (page 98). - **Ed**

Tweets



Paul Martin

@Tyrone_skies • Mar 22

Planet #Venus is so bright in the evening/night sky right now it has to be seen. This is Friday night creating a wonderful glitter path on the sea. Also Pleiades and M31 visible. @VirtualAstro @skyatnightmag @ILoveNorthCoast @AstroBackyard #astronomy #Astrophotography



SOCIETY IN FOCUS

At the **Astronomical Society of Edinburgh** (ASE) we ran our second Telescope Help Shop in February. A wide range of budding astronomers came along, from children to retired people, and they brought along their telescopes so they could learn how to use them. We're often contacted by people with a telescope sitting in a cupboard or garage who would love to use them but don't know how to begin. The Help Shop gets them started, with more experienced members of the society showing them how to set up the mount, align the finder, get an image into focus and point it at an object in the sky.

We planned the event so that the Moon would be visible in the daytime sky and we had enough gaps in the clouds that we did manage to see it. There were talks on subjects such as mounts, eyepieces and observing checklists and we introduced the ASE-24: *Observing List for Beginners*, a useful guide for new observers.



The Help Shop is part of our 'Four Steps to the Stars' programme for beginners, with Choosing a Telescope, Navigating the Night Sky and Intro to Astro imaging.

Normally we meet on the first Friday of every month and visitors are welcome, but because of COVID-19 we are continuously updating our website, Twitter feed and Facebook page.

Mark Phillips, ASE web and media officer
► www.astronomyedinburgh.org

COVID-19

Events cancelled?
Get your astro
fix online
instead

Our pick of the best online events from around the UK

WHAT'S ONLINE



PODCASTS

Radio Astronomy

Make sure you catch the *BBC Sky at Night Magazine* team discussing the latest space and astronomy news. There's also a stargazing tip and interviews with experts like Professor Jim Al-Khalili.

skyatnightmagazine.com/podcasts

ONLINE LEARNING

Moons

If you've not yet discovered Future Learn, now's a great time to deepen your understanding of the Universe with one of its online courses. Try the free 8-week course exploring the Solar System's many moons. futurelearn.com/courses

CITIZEN SCIENCE

Zooniverse

Zooniverse connects thousands of people to tackle research topics together. Take a look at the many highlighted space topics that currently need volunteers on the 'Projects' page. zooniverse.org

ONLINE TALKS

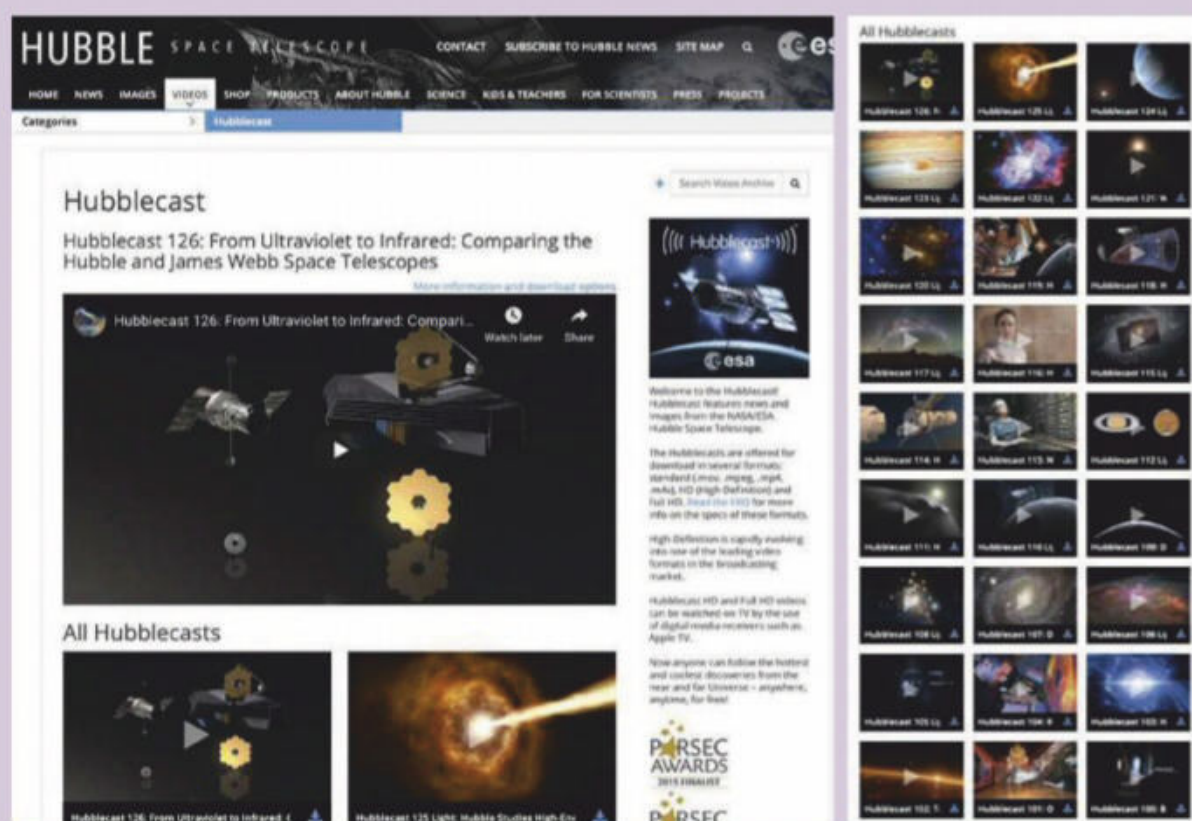
The Scientific Now of Food

Scientist and biochemist Sarah Kessans' fun lecture explores how we'll produce food when we live on Mars. bit.ly/2WRTOiu

Cassini – The Grand Finale

Saturn fans will enjoy this Royal Astronomical Society talk from Professor Michele Dougherty, as she unpacks the findings from the last months of the Cassini programme. bit.ly/2vWz1G

PICK OF THE MONTH



▲ Background stories: discover the space telescope's amazing achievements in more depth

Hubblecasts: a wonderful Hubble video resource

The Hubble Space Telescope turns 30 this year, but did you know that in addition to furnishing us with countless spectacular images over three decades, ESA and NASA have also created a treasure trove of fantastic Hubble-related videos?

If you've never come across them, there are 120+ to get your teeth into. Most run for about five minutes and they cover topics from the history of the telescope, to its many discoveries and the stories behind those amazing pictures. It's an excellent source for fleshing out the science, with highlights including a look at galactic

mergers (episode 76) and Hubble's unprecedented view of the Eagle Nebula's Pillars of Creation (episode 82). Hubblecast 102 explores what Hubble's exoplanet observations can tell us about their atmospheres, and don't miss episode 113, a short documentary on Nancy Roman, 'the mother of Hubble' who was instrumental in making the giant telescope a reality.

With some top-notch graphic effects to boot, these films really reward watching on a big screen rather than just on your mobile.

bit.ly/2UBqcDs

APPS

SkyView

In a crowded field this free augmented reality app is a great choice, especially for beginners. Point your phone at the sky and reveal stars, planets, constellations, other celestial bodies and even ISS and Hubble passes. Available for both Android and iOS.

DOCUMENTARIES

The Silicon Valley Space Race

There's a new race for space under way between tech titans Jeff Bezos and Elon Musk. This short documentary looks at how both are throwing their considerable wealth into conquering space.

<https://bbc.in/3aoouMs>

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Sky at Night MAGAZINE

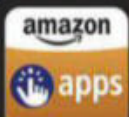
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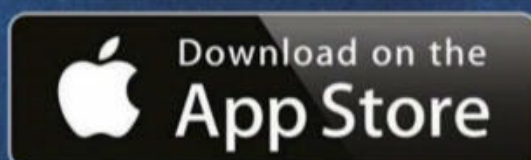
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The perfect addition to your stargazing, *BBC Sky at Night Magazine* is your practical guide to astronomy, helping you to discover the night skies, understand the Universe around us and learn exciting techniques for using your telescope.



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BBC
Sky at Night
MAGAZINE

FOR EVERY ASTROPHOTOGRAPHER



Image of M51, courtesy of Zoltan Nagy

THERE'S AN ATIK

Whether you choose to explore stunning wide field vistas or focus on Arp's peculiar galaxies; no matter what your level of expertise, we'll have the camera for you.

If you're looking for dedicated video astronomy then the Infinity camera will deliver deep sky to screen in seconds. The high speeds and high quality of our Horizon II CMOS camera will lend itself to both planetary and deep sky imaging. If it's a highly sensitive, affordable cooled CCD camera you have in mind, our 4-series will have a camera for you. Or maybe you would prefer the fully integrated solution of the Atik One, or our exceptional large format cameras that will deliver stunning full frame results.

Explore our range of quality cameras made by astrophotographers for astrophotographers. See our website for more details, invaluable advice, tips and tricks, and much more.



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FIELD OF VIEW

How will we greet the next great comet?

It's almost a quarter of a century since we last saw a bright, showstopper of a comet. When the next one appears, events may pan out a bit like this



Stuart Atkinson is an amateur astronomer and writer. Read more of his poetry inspired by the Universe at <https://astropoetry.wordpress.com>

When I was standing in the middle of the famous Castlerigg Stone Circle on a chilly April night in 1997, marvelling at the sight of Comet Hale-Bopp's twin

tails shining above the ancient standing stones, if you'd told me I'd still be waiting to see another great comet almost a quarter of a century later I'd have laughed at you. What a ridiculous idea! But you'd have been right.

Last night I was photographing another comet, T2 PanSTARRS, but to call it a pale imitation of Hale-Bopp would be overly kind. It's little more than an out of focus, slightly greenish smudge passing the ridiculously pretty spilled jewels of the Double Cluster. I haven't even seen it with my own eyes yet; it's too faint to be seen without a telescope under my light-polluted skies.

Despite a few near misses – including Comet ISON, 'The Comet That Shall Not Be Named', which cruelly fooled us all into thinking it would be spectacular but fizzled out like a United Kingdom Eurovision Song Contest entry – there have been no decent naked-eye comets for years, and frankly I'm sick of waiting.

But the next great comet is out there, right now, somewhere, just waiting to be found.

It will first appear on a survey image as a tiny smudge, sandwiched between scratched Starlink trails. Nothing special at first glance, but after it has been observed for a few nights, crunching its orbital numbers will reveal it is destined to be 'The Next Hale-Bopp' in a year or so's time. And then, in our modern age ruled by the internet and social media, when it shines in our sky, astronomers, the media and the public will all go a bit, well... nuts.

By the time it is bright enough to be seen with the naked eye, the comet – let's call it Comet Jess – will already be all over the internet. There will be countless Facebook pages and groups dedicated to it, and it will have its own hilarious Twitter account too. Despite astronomers' reassurances that it will miss us by many millions of kilometres, YouTube will already be groaning under the weight of nut job videos predicting Comet Jess will shower Earth with lethal alien microbes, knock Earth out of its orbit or simply smash into us, killing everything on it. And, of course, the Nibiru disciples will declare they were right all along...

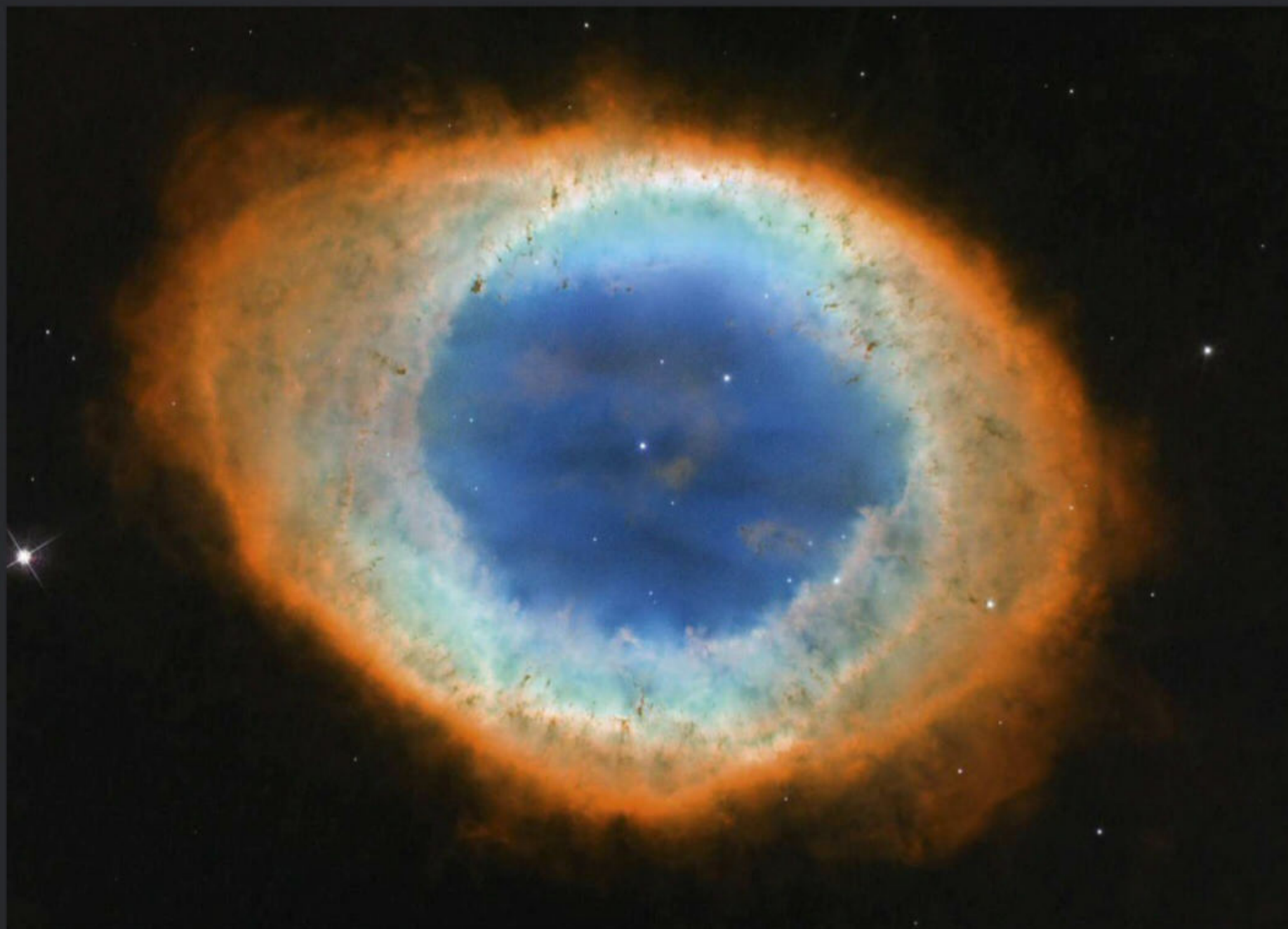
But none of that will matter, because when Comet Jess is hanging there in the evening twilight, its long tails streaming across the sky like pennants flying from the turret of a medieval castle, comet fever will take hold of the world. Astronomical societies will organise 'Comet Watch' evenings, attended by huge crowds; every day thousands more images of the comet will be posted online, many taken by smartphone cameras better than Hale-Bopp era SLRs; people will stop and stare at it from supermarket car parks and outside pubs. Crowds will gather in parks, country laybys and school playing fields to marvel at the beautiful sight in the sky. It will be on every TV weather report, in every newspaper and on more websites than a picture of a sleepy kitten falling off a sofa.

I can't wait. 🌀

► Read our feature looking at great comets of the past on page 64.

HIGHLIGHTS OF HUBBLE

We celebrate the greatest pictures of the last 30 years – see more on pages 40 and 59



▲ Ring of power

CAPTURED: 23 MAY 2013

Hubble has helped to define the shape of the Ring Nebula, revealing it to be doughnut shaped, with lower density material at its core.

Shrinking storm ►

CAPTURED: 27 JUNE 2019

Revealing the detailed beauty of Jupiter's clouds, this image shows the intense colour palette of the Great Red Spot and is proof that the storm – which has raged for over 150 years – is shrinking.





Pillars of strength

CAPTURED:
5 JANUARY 2015

One of Hubble's most iconic images, the Eagle Nebula's Pillars of Creation unveils the multicoloured glow of gas clouds interspersed with wispy tendrils of dark cosmic dust. Originally captured in April 1995 (see inset), the new image was released almost 20 years later. It captures more detail on the rust-coloured elephant trunks of the nebula's legendary pillars. The dust and gas in these is seared by the radiation from nearby young stars. The nebula is 7,000 lightyears away.



HUBBLE
SPACE TELESCOPE
30

NASA/ESA/M. ROBERTO (SPACE TELESCOPE SCIENCE INSTITUTE/ESA) AND THE HUBBLE SPACE TELESCOPE ORION TREASURY PROJECT TEAM, HUBBLE HERITAGE TEAM (AURA/STSCI/NASA/ESA), NASA/ESA, EUROPEAN SPACE AGENCY & NASA

▲ Orion up close

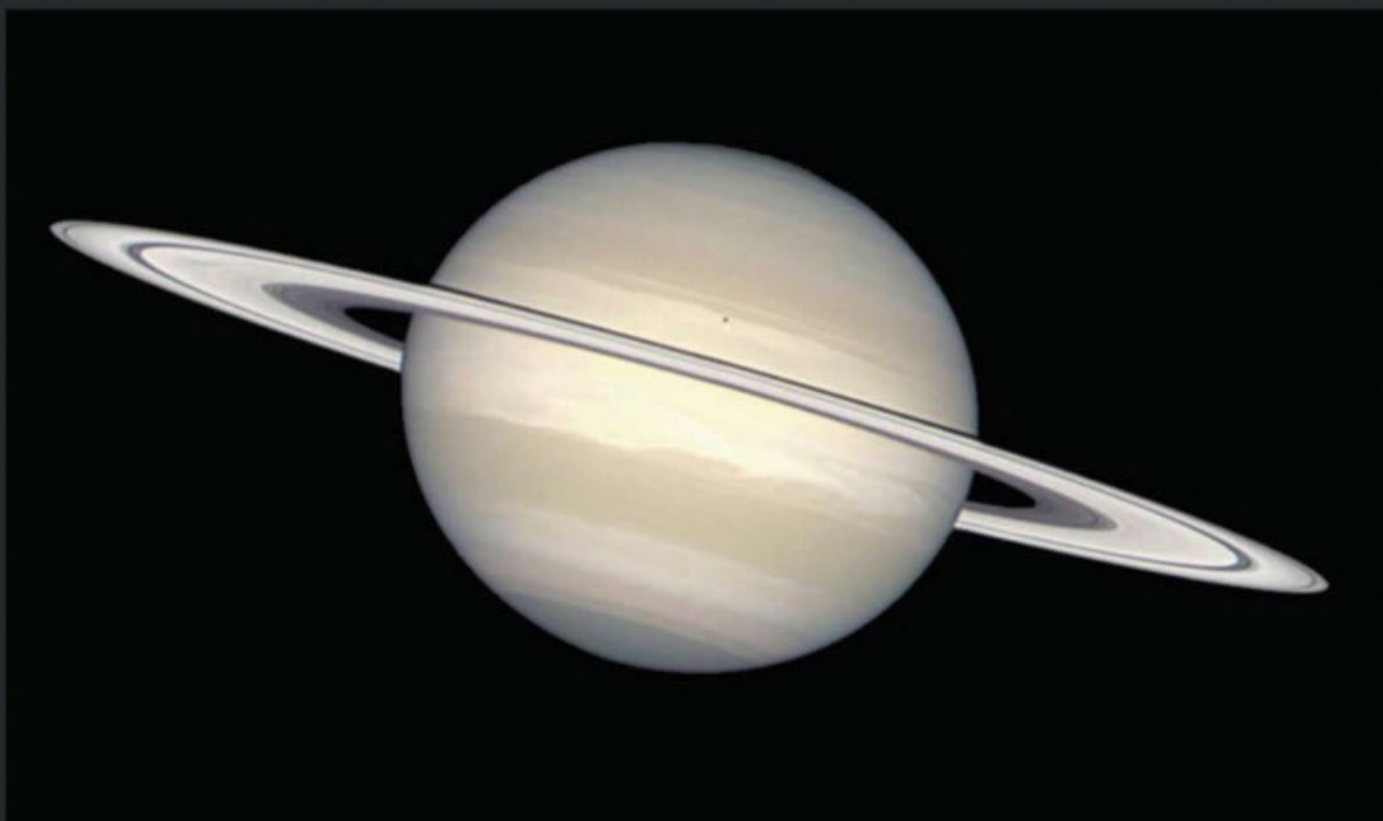
RELEASED: 11 JANUARY 2006

The sharpest view ever taken of the Orion Nebula, 1,500 lightyears away, reveals over 3,000 stars of differing sizes nestling within the vast cavern of rolling dust and gas.

Saturn, naturally ►

RELEASED: 21 OCTOBER 1998

Hubble's image-processing specialists worked on presenting this extremely accurate view of Saturn's pastel colours, highlighting the subtle differences in the clouds.



HIGHLIGHTS OF HUBBLE

◀ Crab of many colours

CAPTURED: 1 DECEMBER 2005

This most detailed view of the Crab Nebula was assembled from 24 individual exposures. The expanding remnant of a star's supernova explosion is revealed in glorious colourful detail, with orange hydrogen filaments and the nebula's bluish interior glow.

▼ Supergiant star factory

RELEASED: 28 FEBRUARY 2006

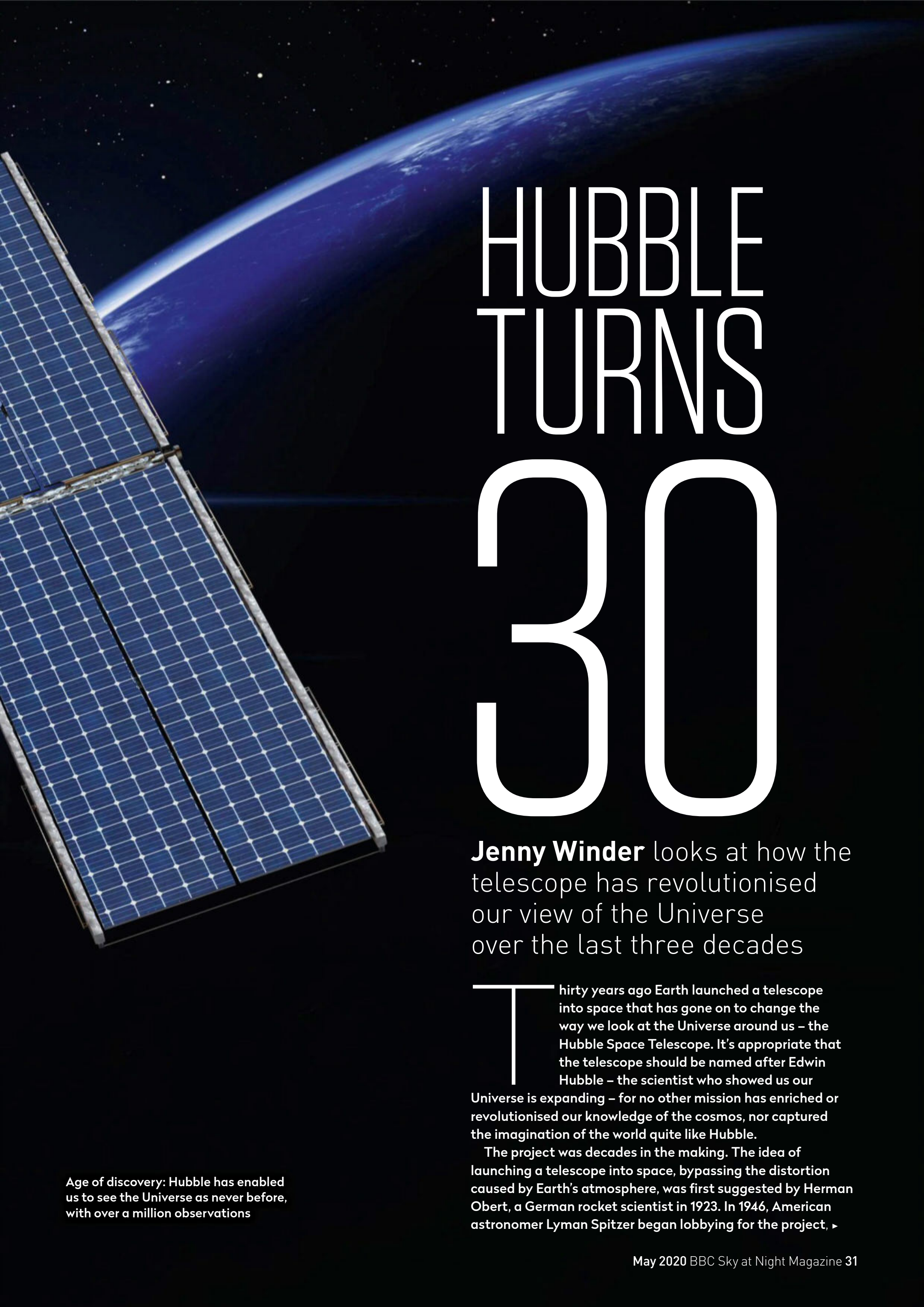
Hubble's stunning image of the gigantic Pinwheel Galaxy, M101, was captured over 10 years. It shows the detail of the galaxy's spiral arms, which are sprinkled with large regions of star-forming nebulae.





HUBBLE
SPACE TELESCOPE
30

MAXIM ZHURAYEV/ISTOCK/GETTY IMAGES, BLACKJACK3D/ISTOCK/GETTY IMAGES



HUBBLE TURNS 30

Jenny Winder looks at how the telescope has revolutionised our view of the Universe over the last three decades

Thirty years ago Earth launched a telescope into space that has gone on to change the way we look at the Universe around us – the Hubble Space Telescope. It's appropriate that the telescope should be named after Edwin Hubble – the scientist who showed us our Universe is expanding – for no other mission has enriched or revolutionised our knowledge of the cosmos, nor captured the imagination of the world quite like Hubble.

The project was decades in the making. The idea of launching a telescope into space, bypassing the distortion caused by Earth's atmosphere, was first suggested by Herman Obert, a German rocket scientist in 1923. In 1946, American astronomer Lyman Spitzer began lobbying for the project, ►

Age of discovery: Hubble has enabled us to see the Universe as never before, with over a million observations



Hubble is deployed: the Space Telescope is placed in orbit by the Space Shuttle Discovery on 25 April 1990

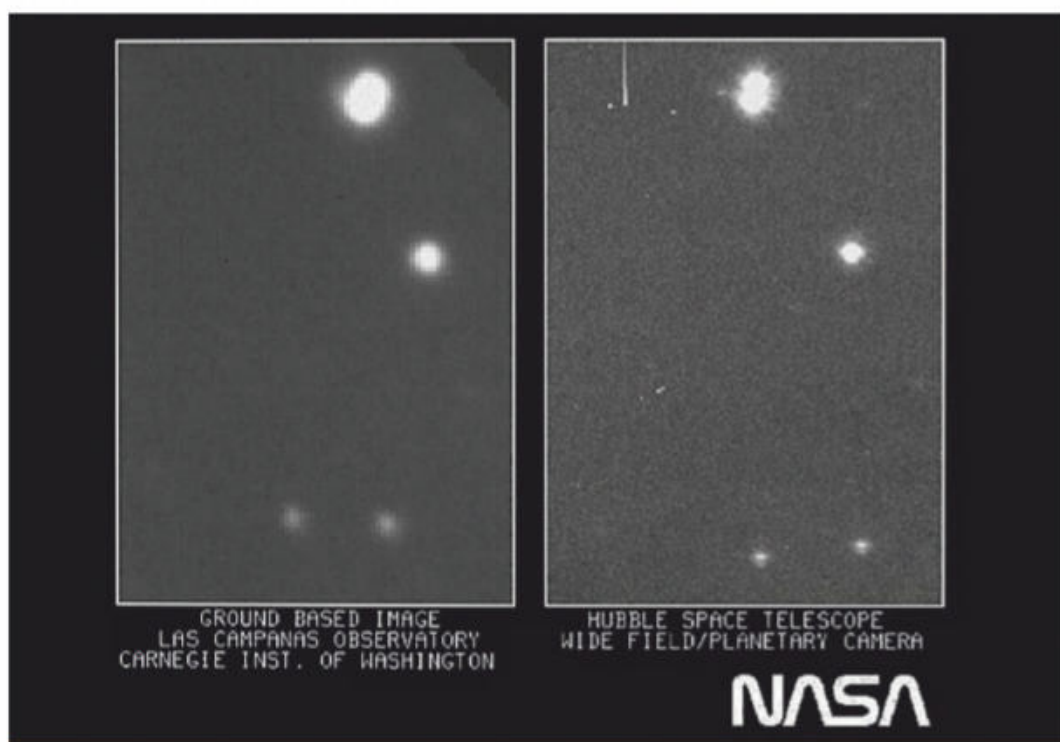
► but it was not until 1969 that NASA officially took up the proposal and published a report on the scientific advantages of what was then called The Large Space Telescope. The first working group was held in 1974 and \$36m of funding was finally approved by Congress in 1978. The European Space Agency then came on board, contributing extra funding and expertise.

The path to the launchpad was far from smooth, however. The telescope was meant to be launched onboard a Space Shuttle in 1983, but problems with the mirror meant the project slipped increasingly behind schedule and over budget. Eventually a launch date of September 1986 looked possible, only for the Challenger disaster in January that year to halt all Shuttle flights. Delayed for another four years, the budget increased to an eye-watering \$4.7bn.

Getting off the ground

Elsewhere, budget constraints meant the original plan of having a 3m mirror had to be reduced to 2.4m. This would be capable of accommodating five scientific instruments at once. At launch these were the Wide Field and Planetary Camera (WFPC), Goddard High Resolution Spectrograph (GHRS), High Speed Photometer (HSP), Faint Object Camera (FOC) and Faint Object Spectrograph (FOS).

Space Shuttle flights resumed in 1988 and finally on 24 April 1990, Space Shuttle Discovery mission STS-31 lifted off from the Kennedy Space Center and the



following day Hubble Space Telescope launched into a geocentric orbit about 550km above Earth, where, travelling at a speed of 28,000km/h, it orbited once every 97 minutes.

As soon as the first images were received it was obvious there was a serious problem with the optics. Instead of sharp pin point images, stars were surrounded by fuzzy halos. This was a devastating blow. Though the telescope could still carry out some observations of bright objects, any faint observations

▲ **First light:** Hubble's first image (right), on 20 May 1990, shows a region in Carina with sharper stars than a ground-based comparison (left) taken in Chile

Edwin Hubble

Edwin Powell Hubble was born in Missouri in 1889. To please his father he studied law, but after his father died he returned to university to gain a PhD in astronomy. After serving in World War One, he took up a post at the Mount Wilson Observatory.

At this time it was widely believed that our Milky Way Galaxy was the entirety of the Universe. By studying Cepheid variable stars in faint 'nebulae', Hubble proved these were too distant to be part of our Galaxy, instead being galaxies in their own right. In 1929 he observed that the velocity of such galaxies was proportional to their distance from Earth, the first

evidence for the expansion of the Universe – although Hubble himself believed his observations pointed to a flat and homogenous Universe and rejected the expansion theory.

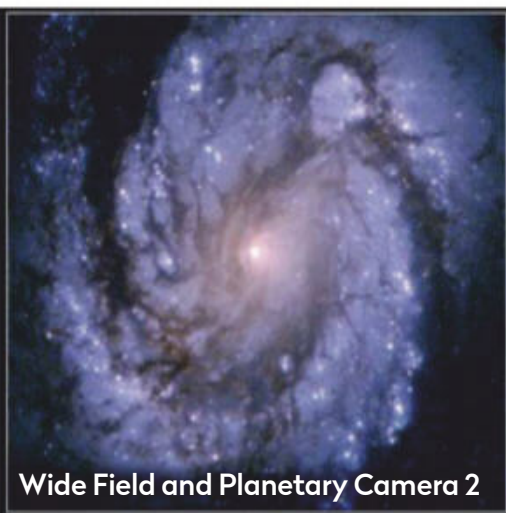
One of the Hubble Space Telescope's primary missions was to build on his work, and accurately measure the distances of Cepheid variable stars and refine the 'Hubble Constant' relationship of galaxies' velocities and their distance from us. By studying distant supernovae, it provided evidence that instead of decelerating under the influence of gravity, the expansion of the Universe was accelerating, an effect now attributed to dark matter.



Visionary: Edwin Hubble proved there was more to the Universe than just the Milky Way



Wide Field and Planetary Camera



Wide Field and Planetary Camera 2



Wide Field and Planetary Camera 3

▲ Improved optics: three images of M100 (left to right) show how Hubble's image quality has improved – with shots from 1993, 1994 and 2009

were impossible. By analysing the images, the Hubble team soon discovered that a microscopic error on the outer edge of the primary mirror meant the mirror was polished too flat.

On any other telescope, this would have been terminal, but Hubble had been designed to be maintained and upgraded in space using the Space Shuttle. While this couldn't replace the primary mirror, a second-generation camera for Hubble, the Wide Field and Planetary Camera 2 (WFPC2) was already in development and, with the aid of some corrective optics, NASA hoped to compensate

for the flaw in the mirror.

The first servicing mission by Space Shuttle Endeavour launched in December 1993. As well as installing the new optics, the team replaced the solar arrays, four gyroscopes, two magnetometers

and other electrical components as well as upgrading the onboard computers to keep the telescope running as long as possible.

Hubble under threat

By January 1994 the first pin-sharp images to be received showed that the ambitious and perfectly executed mission had worked. NASA had snatched victory from the jaws of defeat.

Subsequent service missions have been carried out periodically during Hubble's lifetime. However, in 2003, all services were thrown into doubt when the Space Shuttle Columbia broke up during re-entry. NASA decreed that all future Shuttle missions must have the capability to dock with the International Space Station (ISS) as a safety precaution. As Hubble was on a different orbit to the ISS, this would not be possible.

There was an outcry from both astronomers and the public and a sustained campaign was mounted to rescue Hubble. Finally in 2006, NASA gave the ►

Many of Hubble's images have become cultural icons, appearing on everything from album covers to coffee mugs

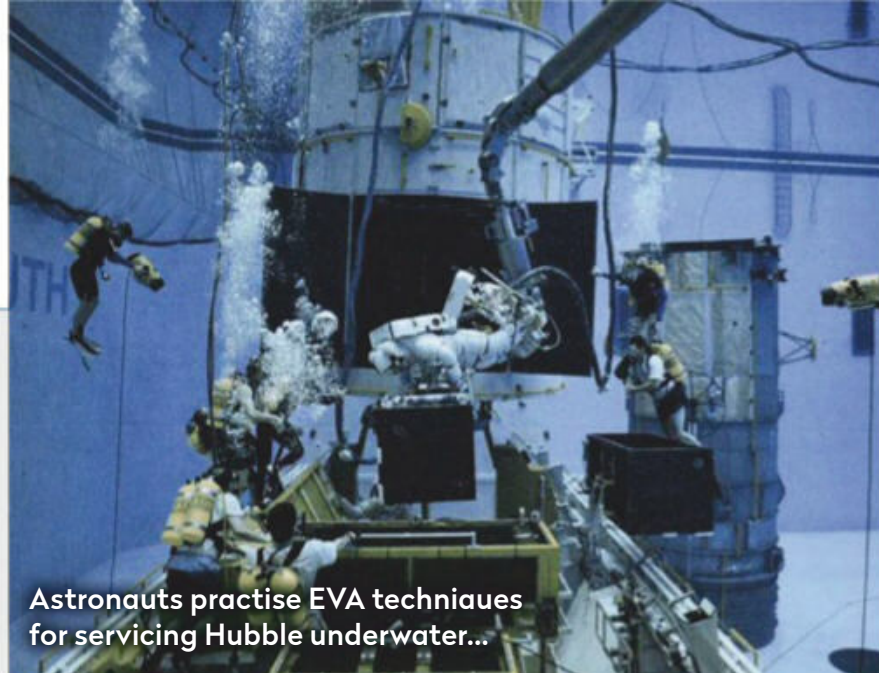
Servicing missions

The Hubble Space Telescope was the first spacecraft designed to be maintained, upgraded and repaired by astronauts while still in space. Over the years, it's had five such servicing missions all staged from the Space Shuttle. Before each, astronauts trained rigorously, simulating the spacewalks required and testing the hardware to be installed.

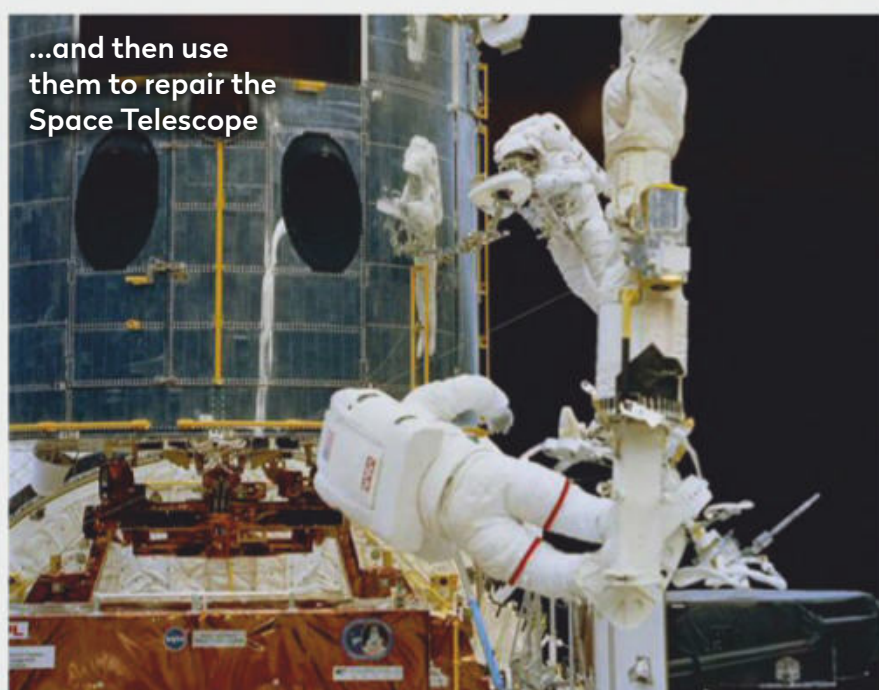
During these missions the Space Telescope Operations Control Centre (STOCC) placed Hubble into hibernation and closed the cover to protect its optical equipment. They then manoeuvred the telescope into position where the Shuttle's robotic arm could grab the telescope and place

it in the payload bay. With Hubble anchored in place, astronauts could undertake three to five spacewalks to install new instruments or repair existing ones.

Ground crew would then test the new additions before preparing Hubble for release. The Shuttle would often boost the telescope into a higher orbit to prolong its life, as atmospheric drag is slowly bringing the telescope closer to crashing. The robotic arm would then release Hubble, and STOCC would reopen the aperture door and check all was working as it should. It usually took a few months of further testing before Hubble was back to full science operations after a servicing mission.



Astronauts practise EVA techniques for servicing Hubble underwater...



...and then use them to repair the Space Telescope

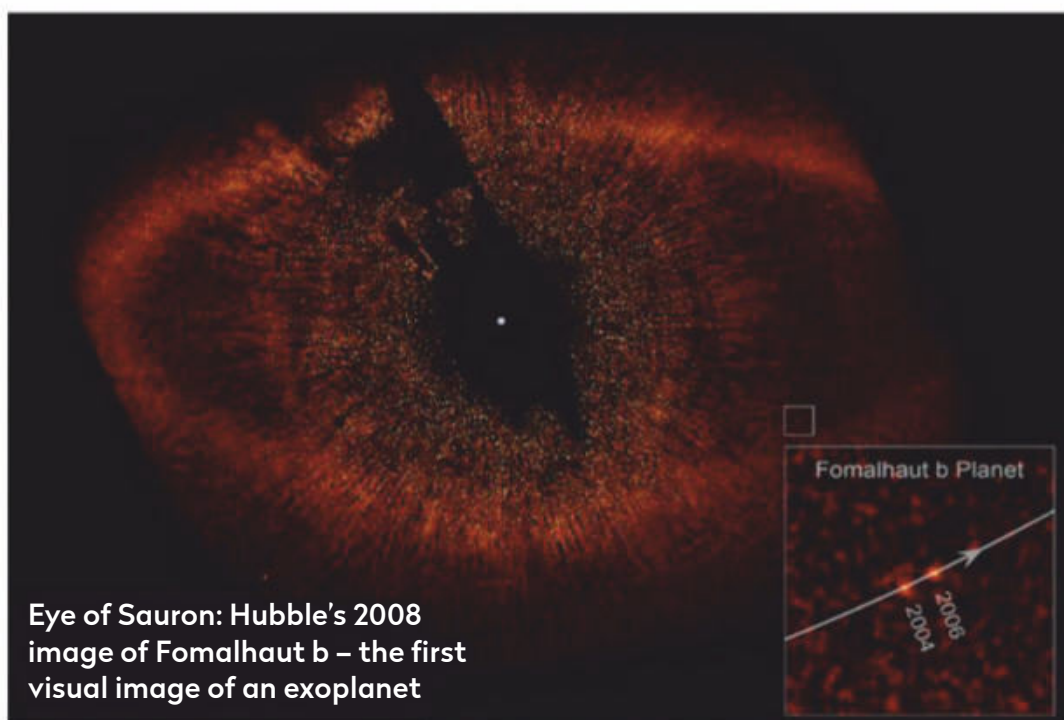
► go ahead for a final servicing mission and not a moment too soon. In 2008, the main data-handling unit on board the telescope failed, leading to a month-long black out of all scientific data.

In May 2009, Atlantis flew the last service mission. It replaced the primary data-handling unit repaired two other instruments. Wide Field Camera 3 (WFC3) and Cosmic Origins Spectrograph (COS) were installed and a Soft Capture Mechanism (SCM) was also put in. This would allow a future mission, either crewed or robotic, to perform a safe controlled deorbit when Hubble finally reached the end of its mission.

Pioneering science

Throughout the last three decades, Hubble has played a role in investigating almost every area of astronomy. The telescope has found new star-forming regions and informed our knowledge of planetary formation. It has looked at galaxies that formed when our Universe was just three per cent of its current age and informed us that a black hole lies at the heart of most galaxies. It has helped to determine the size and mass of our Milky Way Galaxy, created a 3D map of dark matter, helped to characterise dark energy, pinned down the rate that our Universe is expanding and measured the age of the Universe to 13.7 billion years. In 2016 Hubble data revealed the oldest and farthest known galaxy, GN-z11, which is 32 billion lightyears away, meaning we see it as it was 400 million years after the Big Bang.

In 2001 Hubble was able to measure the elements present in the atmosphere of the exoplanet HD 209458b and in 2008 took the first ever visual image of an exoplanet (Formalhaut b). It was the

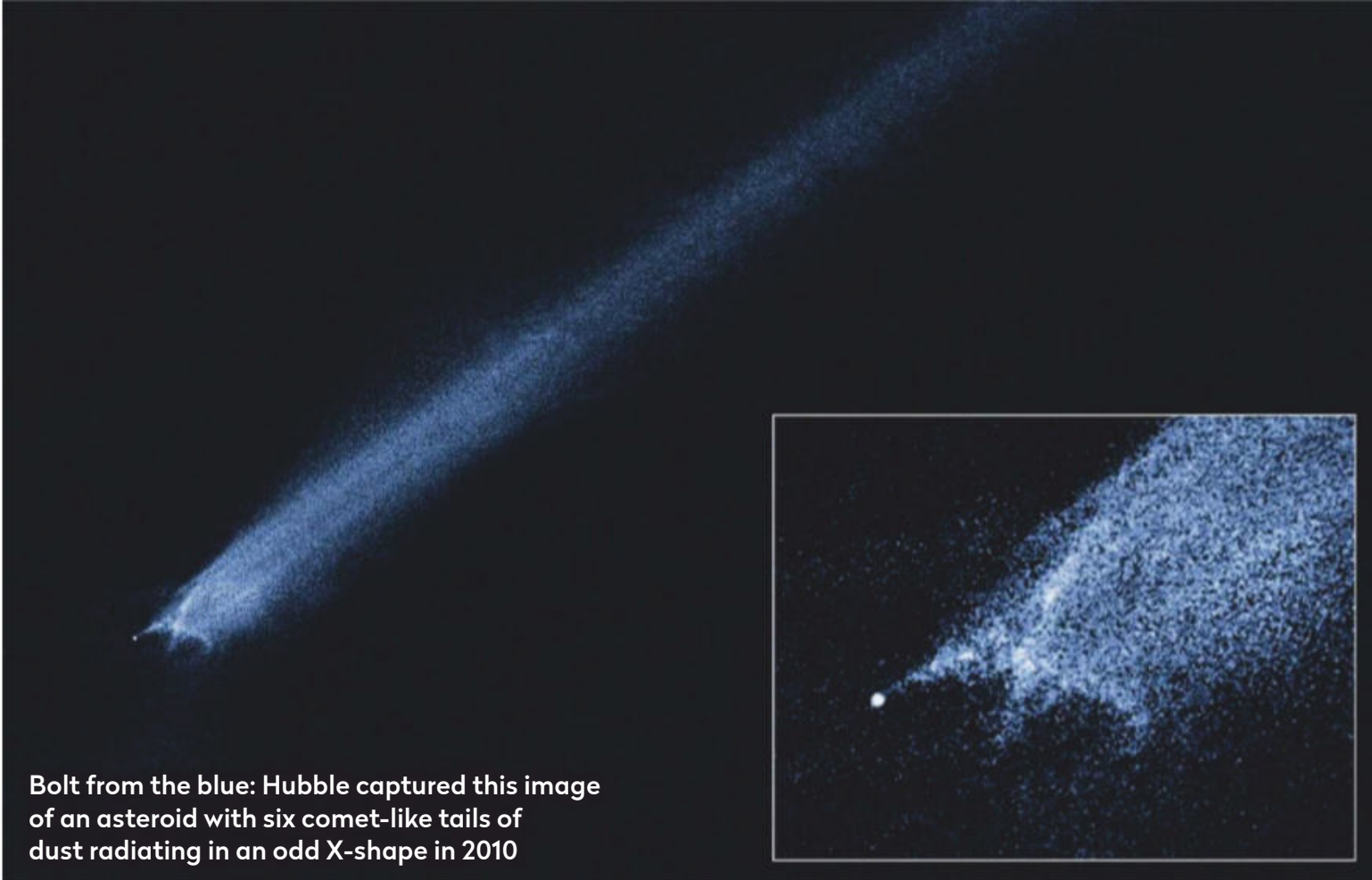


Eye of Sauron: Hubble's 2008 image of Fomalhaut b – the first visual image of an exoplanet

first telescope to determine the true colour of an exoplanet and created the most detailed weather map of one. It found evidence of two asteroids colliding for the first time and observed the disintegration of another. Hubble discovered Pluto's moons Styx, Hydra and Nix and in 2015 located five new Kuiper belt objects when it was used to find a target for the New Horizons mission. In 1994 it witnessed the impact of comet Shoemaker-Levy 9 on Jupiter. It has found jets of water vapour erupting on the surface of Jupiter's moon Europa and, by measuring the aurorae on Ganymede, determined there must be a 100km-deep subsurface ocean beneath the 150km ice crust. Hubble even caught the



Jenny Winder is an astronomy writer, journalist and broadcaster



Bolt from the blue: Hubble captured this image of an asteroid with six comet-like tails of dust radiating in an odd X-shape in 2010

take deep images of over 250,000 galaxies, exploring the evolution of the early Universe from less than a billion years after the Big Bang. The telescope looked at five different areas

first predicted appearance of a supernova in a distant galaxy cluster, and earlier this year Hubble discovered that the Sombrero Galaxy, M104, had undergone mergers with other galaxies in the past. And these are just a few of the discoveries Hubble has made out of a catalogue of hundreds.

In its 30 years, Hubble has carried out several major observation campaigns, the largest being the Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS). This used Hubble to

of the sky, studying them in the many wavelengths available to it and other survey telescopes.

In 2006, the Cosmic Evolution Survey (COSMOS) used Hubble, alongside many other major telescopes, to study a two square degree patch of sky, 17 times larger than any of the CANDELS regions. Over two million galaxies were detected, covering 90 per cent of the age of the Universe. Another project, the Hubble Deep Fields Initiative, used gravitational lensing to study high-redshift galaxies that are ►

Hubble's glasses

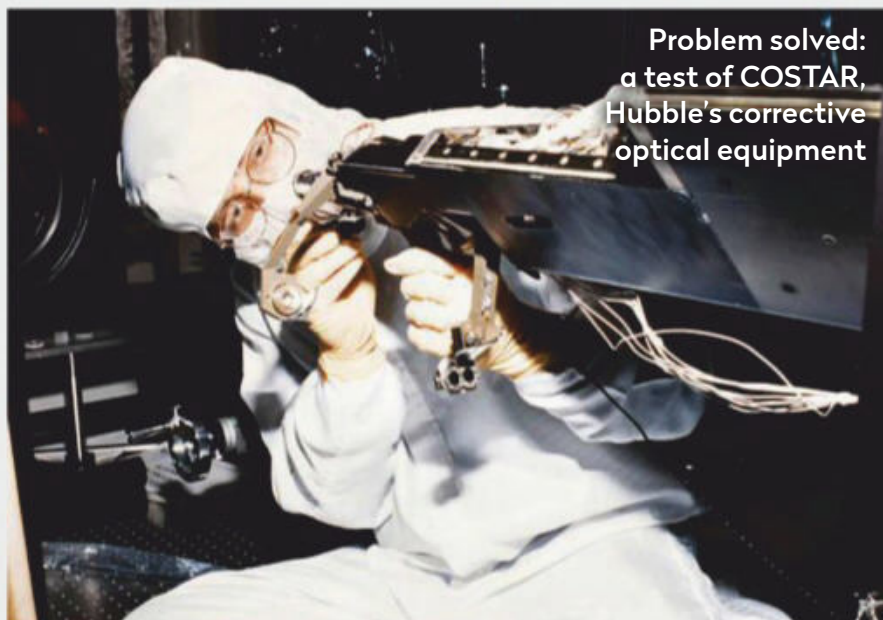
As the first images from Hubble came down to Earth, it was obvious all was not well and it wasn't performing as it should. After a few weeks the problem was identified – the primary mirror was just 2 microns too shallow, around one 50th the width of a human hair. Hubble couldn't reach the sharp focus it was meant to. Rather than collecting 70 per cent of starlight to a focal

point, Hubble was only able to collect 10 to 15 per cent. Luckily the upgraded WFPC2 was being built and engineers could adjust the optics to compensate for the flaw.

This didn't solve the problem for all the other instruments onboard, however. A set of smaller corrective mirrors, named the Corrective Optics Space Telescope Axial Replacement

(COSTAR) were also developed to focus the images for the other scientific instruments. COSTAR consisted of five pairs of small mirrors on deployable arms, with 12 motors and over 5,000 individual parts, that could be positioned to intercept and refocus the light from the primary mirror into the two remaining spectrographs and FOC.

It launched on Space Shuttle Endeavour in December 1993, on the most complex Shuttle mission ever performed. It took the seven astronauts, 10 days and five spacewalks to install the new equipment. The mission went off without a hitch and when the first pin sharp images came through, they knew it had been a complete success. Hubble was back in business.



Problem solved: a test of COSTAR, Hubble's corrective optical equipment



Job done: Hubble's COSTAR is removed in 2009 to make way for new equipment

The people's telescope

Everyone loves a comeback story and Hubble's is one of the best. When it launched it was already over budget and behind schedule. Then the first flawed images came out and both Hubble and NASA became a laughing stock. They were lampooned in the media and seen as an expensive waste of taxpayer's money. However, the repair mission was so audacious and the final images so breathtaking that the public ultimately fell in love with the space telescope.

The number and importance of news stories about Hubble's images and discoveries have outstripped all other missions – including Apollo. While Hubble's scientific discoveries are

many and groundbreaking, you don't have to be a scientist to appreciate the sheer beauty of the images it has returned. Hubble's images have been used in TV shows from *Star Trek Voyager* to the *Big Bang Theory* and have changed the way space is portrayed in movies – from empty blackness to being filled with vivid colours. Iconic images, like the Pillars of Creation (right) and the Ultra Deep Field, along with incredible views of planets and nebulae, galaxies and star clusters, moons and dying stars, all seen in unprecedented detail, have taken astronomy into the mainstream and brought the wonders of the cosmos to everyone.



Iconic: Hubble's stunning 2015 image of the Eagle Nebula's Pillars of Creation

► around 10 to 50 times fainter than any of the ones previously studied.

One particular set of images, Hubble's Deep Field Observations, includes, perhaps, some of the most astonishing images ever produced. In December 1995, Hubble took 342 exposures over 10 consecutive days of the same tiny patch of sky in the constellation of Ursa Major – an area covering roughly one 24-millionth of the entire sky.

In 1998 a similar area of the Southern Hemisphere in the constellation of Tucana was imaged in the Hubble Deep Field South.

In 2004 the Hubble Ultra-Deep Field covered a small area in the constellation of Fornax containing 10,000 galaxies. It was the most sensitive astronomical image in visible wavelengths ever made until 2012 when the Hubble eXtreme Deep Field was released – covering just a portion of the Ultra-Deep Field.

Keeping track

With so much information to keep track of, the Hubble Heritage Project was founded in 1998 and the following year ESA launched its Hubble Information Centre. These select, process and release images and news bulletins and it is these images that have inspired the public and been hailed for their "outstanding contributions to the public understanding and appreciation of astronomy".

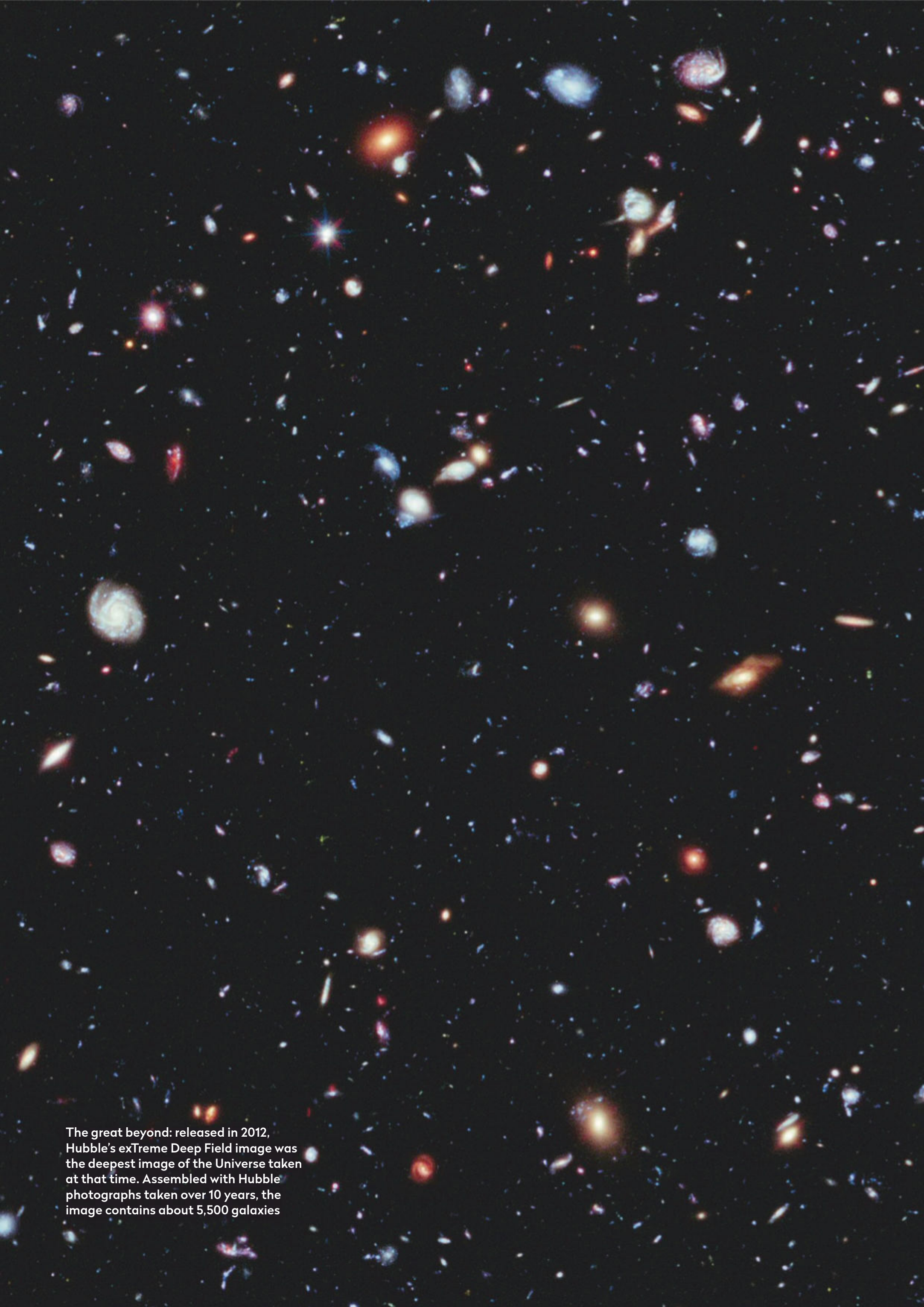
Many of Hubble's images have become cultural icons, appearing not just in science books, but on



everything from album covers to coffee mugs. No other mission has opened our eyes to the variety, complexity and downright beauty of space.

Thirty years on, Hubble is still working productively and estimated to be operational well into 2030 or 2040. Over the three decades of its life Hubble has taken over a million observations and the data it has generated has been published in more than 16,000 peer-reviewed scientific papers, which are referenced on average at a rate of 150 times a day. In 2017 the American government announced it was considering further servicing missions to extend the life of this iconic telescope that has expanded our view of the Universe. 🌌

▲ **Going strong:** one of the last pictures of Hubble, taken during the 2009 service mission. Hopefully, the Space Telescope will be working for many years to come



The great beyond: released in 2012, Hubble's exTreme Deep Field image was the deepest image of the Universe taken at that time. Assembled with Hubble photographs taken over 10 years, the image contains about 5,500 galaxies

The fundamentals of astronomy for beginners

EXPLAINER

The James Webb Space Telescope

NASA's successor to Hubble will reveal the early Universe in unprecedented detail

Back in time:
JWST will search
for traces of
the birth of
the Universe



far-flung location also means that, unlike Hubble, it will be unserviceable.

JWST should start its science observations six months after launch. It will hover at L2 for the next 5.5 to 10 years, and scientists hope it will give us glimpses of the early Universe that we have never seen before. It will be one of the largest, most powerful scopes and should give us new insights into every phase of the Universe's history, from the first dust clouds to our Solar System's formation.

NASA, one of JWST's collaborators along with the European Space Agency (ESA) and the Canadian Space Agency, is keen to point out that JWST is Hubble's successor rather than a replacement. When Hubble was launched 30 years ago, it was the first space-based optical scope and has given us unprecedented views of the Universe. However, it looks at the optical, ultraviolet and near-infrared wavelength ranges. James Webb will look between visible red and mid-infrared light, peering much further back into the early Universe.

Light from the earliest luminous objects travels so far in an expanding Universe that by the time it reaches us,

A new era of space observation is expected to begin in March 2021. Provided there are no further delays, Hubble's heir, the long-awaited James Webb Space Telescope (JWST), should launch aboard an Ariane 5 rocket from French Guiana.

With its tennis court-sized sunshield and 6.5m primary mirror flat-packed inside the launcher like a ship in a bottle, the scope will separate from the rocket half an hour after take-off and deploy within a day.

Over the following 30 days it will travel over 1.5 million km to a gravitationally stable outpost called Lagrange 2 (L2). This lies on a straight line from the Sun to Earth and beyond, so that JWST will be locked into Earth's yearly orbit around the Sun. This means that JWST – unlike Hubble, which orbits Earth, going in and out of our shadow every 90 minutes – will have unobstructed views of the Universe. However, the new telescope's

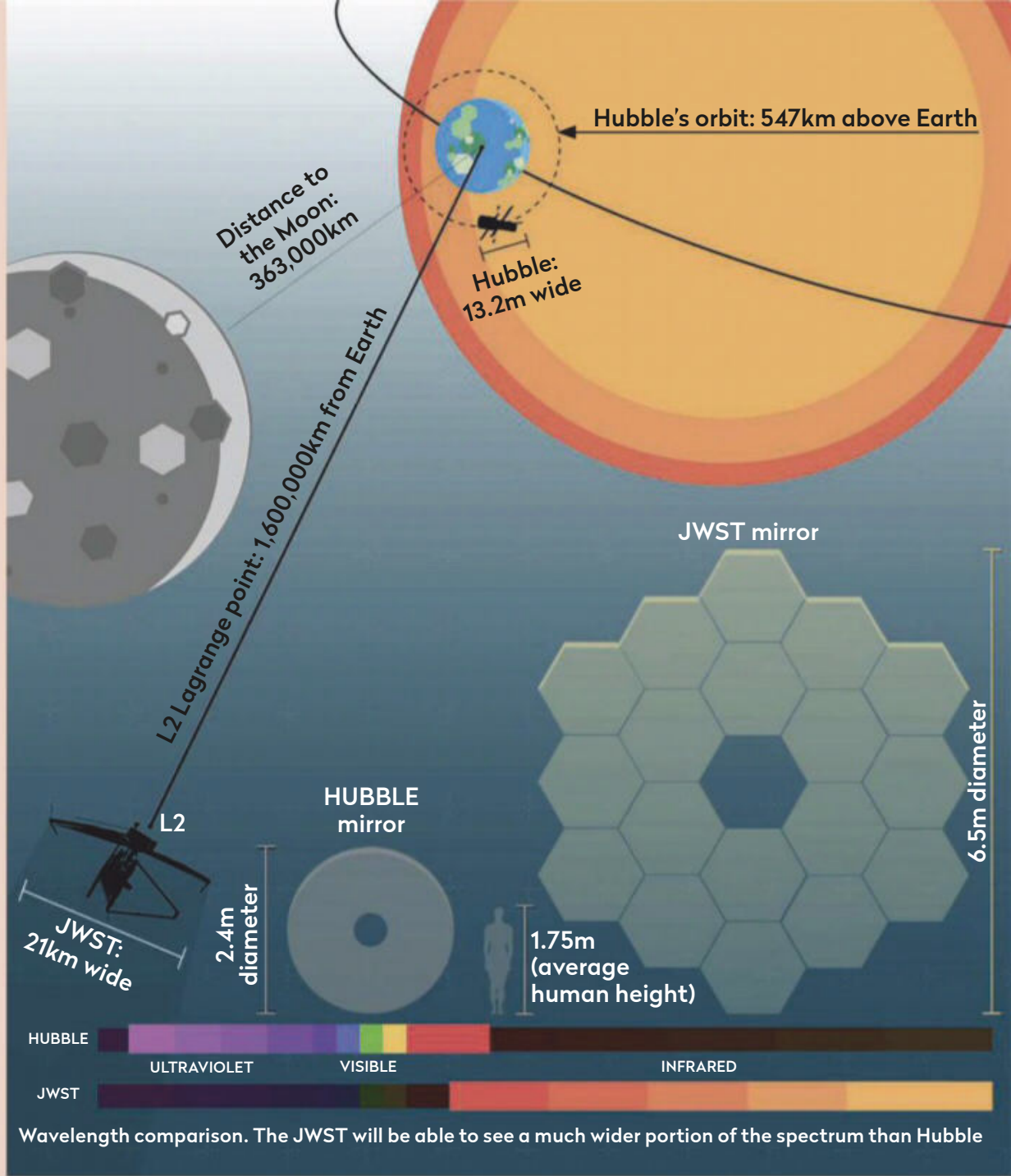
► **Perfect fit:**
the huge JWST
mirror folds so it
can be placed in
a launch rocket



HUBBLE VS JWST

How the James Webb Space Telescope will take space observation to the next level

	HUBBLE	JWST
Distance from Earth	approx. 570km	approx. 1.5 million km
Looks at	optical, UV, to near IR 0.1–2.5 microns	visible to mid IR, 0.6–28.5 microns
Can see as far back as	'toddler' galaxies	'baby' galaxies
Weight	12,246kg	approx. 6,500kg
Diameter primary mirror	2.4m	6.5m
Size	13.2 x 4.2m	22 x 12m (sunshield)
Main telescope size	school bus	half a Boeing 737 aircraft
Temp	21°C	–230°C



its wavelengths have been stretched or 'redshifted'. This means that the earliest Universe is observable only in the infrared part of the spectrum.

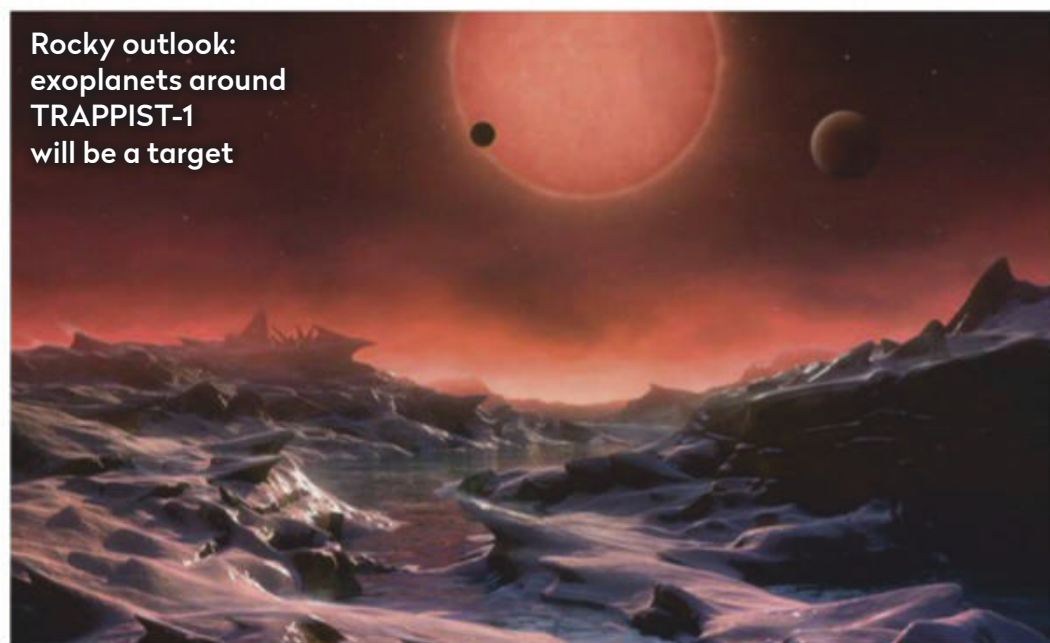
Peering into the past

JWST's larger mirror will enable it to collect over six times the light that Hubble can, with a field of view 15 times the area of Hubble's near-infrared camera and spectrometer (NICMOS). Its primary aim is to probe the so-called 'end of the dark ages' after the Big Bang, when the Universe began to fill with 'first light' from newly ignited stars. It should be able to look back to 100–250 million years after the Big Bang.

But, like Hubble, it is also a general purpose observatory and will specifically look at the birth and assembly of galaxies, the effects of black holes and the origins of life. Scientists hope JWST will help us better understand the Universe's size and geometry, throwing light on dark matter and dark energy, and helping us understand the ultimate fate of the Universe.

Its high resolution means that JWST could give better insights into the Milky Way and our neighbouring galaxies, "extending the work started by Hubble outwards significantly", according to ESA. Similarly, its resolution will enable scientists to see how planetary systems form.

To do all this, JWST will have just four scientific instruments: a near-infrared spectrograph (NIRSpec) which can observe 100 objects simultaneously; a near-infrared camera (NIRCam); a combined mid-infrared camera and spectrograph (MIRI) which has a cryocooler to keep its temperature at –266°C; and a fine



Shaoni Bhattacharya is a science writer and journalist. Her books include: *Secrets in the Skies: Galileo and the Astonishing Solar System*

guidance system and wide-field imager (FGS/NIRISS) that includes a mode for exoplanet spectroscopy.

There are already dome projects planned for JWST. One task will be to observe the atmospheres of potentially habitable, rocky exoplanets in the seven-planet system of TRAPPIST-1, 39 lightyears from Earth. This system was discovered by the Spitzer Space Telescope, which was retired in January. Like James Webb, it specialised in the infrared range, but JWST will be 1,000 times more powerful. Compared to Hubble, JWST is 100 times more powerful and will work alongside it in its final years.

Named after the NASA administrator who oversaw the start of the Apollo Program, JWST has been almost a quarter of a century in the making. Scientists hope it will remain on schedule for its current launch.



High Horse ►

RELEASED:
19 APRIL 2013

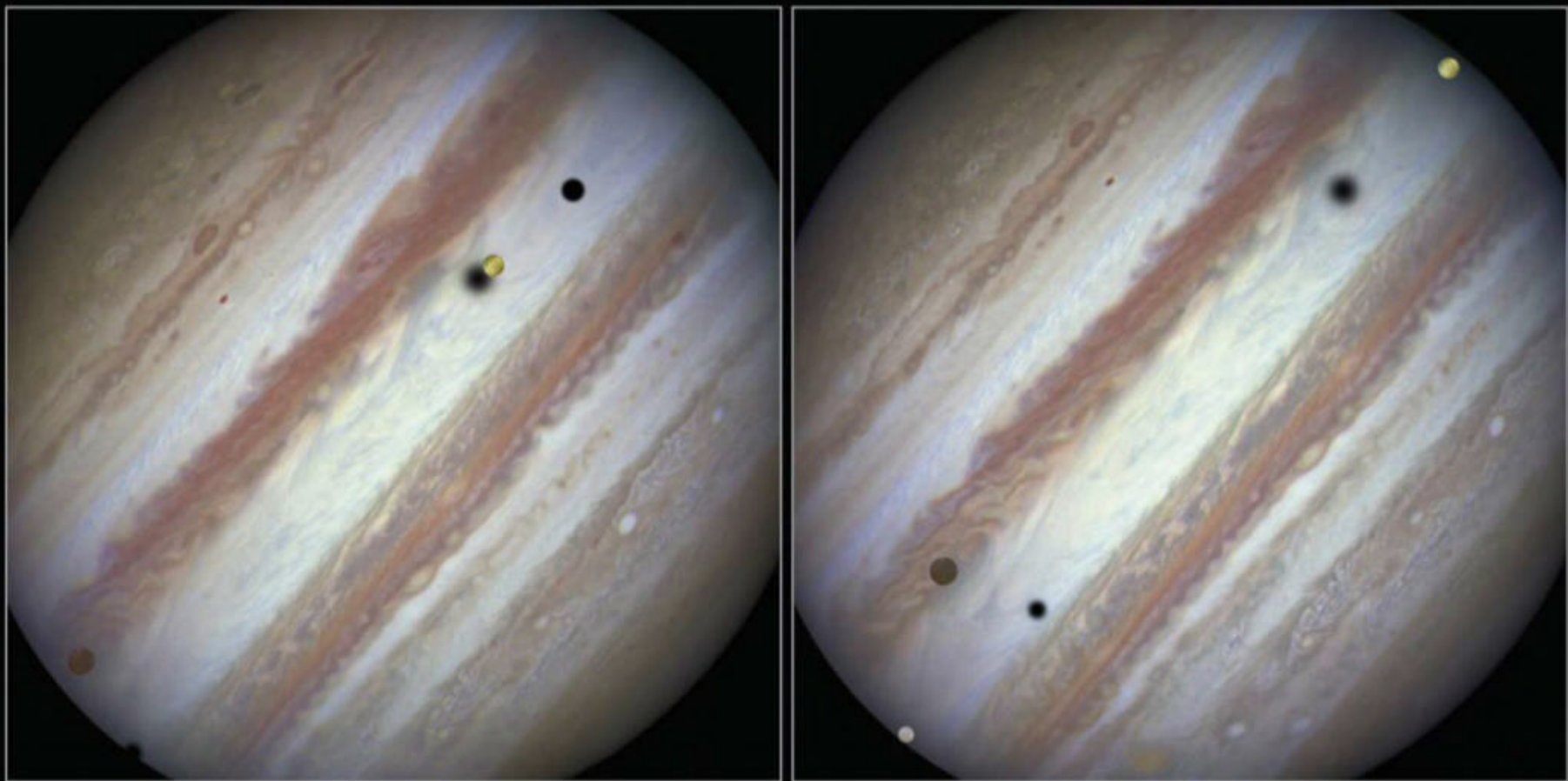
To celebrate its 23rd year, Hubble released this dramatic infrared view of the Horsehead Nebula, revealing a fragile-looking structure with folds of gas and dust.



▲ Cosmic ice sculptures

RELEASED: 16 SEPTEMBER 2010

Hubble captured this extraordinary image that reveals vast pillars made of cold hydrogen and dust – estimated to be one lightyear high – located in the Carina Nebula. At a distance, estimated to be around 7,500 lightyears away, the nebula is sculpted by violent stellar winds and powerful radiation from massive stars. The composite image is constructed from 2,005 Hubble observations.



▲ A parade of shadows

RELEASED:
5 FEBRUARY 2015

In 2015 Hubble captured three of Jupiter’s Galilean moons parading across the planet’s face. The start of the transit (above, left) shows Callisto on the left-hand side with Io on the right. In the next image (above, right) Europa enters on the lower left with slow-moving Callisto above and to its right.

Ancient star swarm ►

RELEASED:
14 NOVEMBER 2013

Located in the constellation of Pegasus, 35,000 lightyears away, M15 is one of the oldest-known globular clusters – dating back 12 billion years. Hubble captured the swarming hot blue and cooler golden stars that become more concentrated towards M15’s bright core.



NASA/ESA AND THE HUBBLE HERITAGE PROJECT (STSCI/AURA) X 3, NASA/ESA



◀ A galaxy divided

RELEASED:
8 JUNE 2006

Hubble's view of NGC 5866 reveals a galaxy in two halves, separated by a crisp dust lane. In this image we can make out the galaxy's structure, including its bright nucleus and transparent outer halo.

Eighth wonder ▼

RELEASED:
12 JULY 2011

In these four images of Neptune, taken a few hours apart, Hubble reveals different faces of the eighth and outermost planet of our Solar System as it rotates on its axis.

Gallery continues after The Sky Guide. Turn to page 59 ▶



NASA/ESA AND THE HUBBLE HERITAGE PROJECT (STSCI/AURA) X 2



The Sky Guide

MAY 2020

VENUSIAN CRESCENT

View Venus, well-positioned
in the evening sky, in its
beautiful crescent phases

SHADOW TRANSIT

Watch Jupiter's moon Callisto
as it moves across the planet

IN CONJUNCTION

Observe a Mercury and
Venus close approach

PETE LAWRENCE

About the writers



Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four



Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ◆ Observe Comet C/2017 T2 PanSTARRS as it reaches peak brightness
- ◆ Three craters are visible bordering Mare Nectaris
- ◆ 42 Isis reaches opposition

Red light friendly



To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at www.skyatnightmagazine.com

MAY HIGHLIGHTS

Your guide to the night sky this month

Friday ►

1 📷 The dazzling evening planet Venus reaches its 25%-illuminated phase today. Venus can be seen shining in the evening twilight at mag. -4.5.

Wednesday

6 📷 Through the eyepiece, Venus currently appears as a 20%-lit crescent, 43 arcseconds across.



Tuesday ►

12 📷 A 74%-lit waning gibbous Moon appears near mag. -2.3 Jupiter and +0.8 Saturn as they rise above the southeast horizon at 02:30 BST (01:30 UT).

📷 Today, Venus is rapidly increasing in apparent size, with 15%-illumination.



Wednesday

13 📷 This morning, the now 64%-lit waning gibbous Moon remains close to planets Jupiter and Saturn. Look for the trio at around 03:20 BST (02:20 UT) when they should be visible low above the southeast horizon.

Sunday

17 📷 Venus is now becoming a slender crescent through the eyepiece of a telescope, today appearing just 10% illuminated.



◀ Friday

22 📷 Mercury and Venus appear just 0.9° apart around 11:00 BST (10:00 UT), during the day.

📷 The evening view will be easier to find, with mag. -0.5 Mercury moving slightly to lie 1.3° from mag. -4.1 Venus.

Saturday

23 📷 This evening look out for a thin 1%-lit waxing crescent Moon near to mag. -0.3 Mercury and -4.2 Venus. Through a telescope Venus now appears as a 5%-lit crescent 54 arcseconds across. Mercury appears 65% lit and 6.4 arcseconds across.

Sunday

24 📷 This evening a 4%-lit waxing crescent Moon lies near to mag. -0.3 Mercury and -4.2 Venus.

Comet C/2017 T2 PanSTARRS appears close to galaxies M81 and M82 in Ursa Major.

Family stargazing



It's the final month that Venus will appear in the evening sky for the current period of visibility. This stunning planet will reach inferior conjunction on 3 June and from thereon in will return to the morning sky. This month, look for Venus every clear evening. Make sure the Sun has set first though. See how long you can follow it before it slips into the Sun's glare. Then, next month, see how quickly you can recover it in the morning sky. It should be visible roughly 30 minutes before sunrise from mid-June onwards.

www.bbc.co.uk/cbeebies/shows/stargazing



◀ Wednesday

27 📷 This evening the 26%-lit Moon appears 2° to the east-northeast of the beautiful Beehive open cluster, M44.

📷 Venus is now at 2% phase.



Saturday ►

2 📷 If you can catch a view of the Moon this afternoon through a telescope you should be able to make out the arc of light known as the Jewelled Handle. This occurs when the Jura mountain range around the edge of Sinus Iridum catches the early lunar dawn light.



Jewelled Handle

◀ Thursday

7 The annual Eta Aquariid meteor shower reaches its peak this morning. Although the shower has a peak Zenithal Hourly Rate (ZHR) of 28 meteors per hour, a low early morning radiant and full Moon in the sky will make this year's display less than spectacular.



Saturday

9 This evening it's the turn of the weak Eta Lyrid meteor shower to reach its peak activity. Although the peak ZHR is only 3 meteors per hour, the shower does have a radiant which is high in UK skies. A bright Moon will interfere.

Wednesday

20 📷 This morning there is a good opportunity to see the shadow of the outer Galilean moon Callisto transiting across Jupiter's disc. The event starts at 01:30 BST (00:30 UT) and ends at 05:13 BST (04:13 UT).

Thursday ►

21 📷 This morning it's Ganymede's shadow that can be seen in transit across Jupiter's atmosphere. The transit starts at 03:40 BST (02:40 UT), mid-transit is at 05:28 BST (04:28 UT) and it ends at 06:55 BST (05:55 UT).



Tuesday ►

26 📷 Noctilucent Cloud (NLC) season opens as we head towards the end of May. Last year gave some amazing displays. What will 2020 have in store?

Venus is now just 3%-illuminated.



Friday

29 📷 Three popular clair-obscure effects occur today. At 15:25 BST (14:25 UT) in daylight the Lunar X and Lunar V will be visible along the terminator. Then at 23:15 BST (22:15 UT), the Face in Albategnius effect will be visible.



◀ Saturday

30 📷 This morning, at 02:00 BST (01:00 UT), Plato's Hook makes its second appearance for the month. Turn to page 55 to find out more about it.

📷 This evening it's the turn of the clair-obscure effect known as the Eyes of Clavius.

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)

Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)

These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly

Objects marked with this icon are perfect for showing to children

Naked eye

Allow 20 minutes for your eyes to become dark-adapted

Photo opp

Use a CCD, planetary camera or standard DSLR

Binoculars

10x50 recommended

Small/medium scope

Reflector/SCT under 6 inches, refractor under 4 inches

Large scope

Reflector/SCT over 6 inches, refractor over 4 inches



GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_easylessons for our 10-step guide to getting started and http://bit.ly/buy_scope for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month



▲ Evening glow: as Venus tracks across the sky from February to May, its apparent diameter grows and its phase shrinks

DON'T MISS

VENUS

Heading towards INFERIOR CONJUNCTION

BEST TIME TO SEE:

All month, easiest at the start of May



Brilliant Venus has been a dominant object in the western half of the sky following sunset for ages, but this month it's all about to change. Venus is an inferior planet, meaning its orbit is smaller and closer to the Sun than that of Earth. From Earth we see Venus in different positions around its entire orbit. When it lines up with the Sun on the far side of that orbit, it's in a position known as superior conjunction.

After this, Venus emerges from within the Sun's glare into the evening sky where it's been for the past few months. It takes a while to 'get going' from this point as it's on the far side of its orbit from Earth.

Through a telescope after superior conjunction, the planet looks like a tiny gibbous Moon. As the days and weeks pass, Venus slowly moves closer to Earth. Its apparent diameter grows and its phase shrinks.

When the Earth–Sun–Venus angle reaches 90°, we see the planet with a 50% phase, or thereabouts. An atmospheric phenomenon known

as the Schröter effect, causes the 50% phase to appear a few days early in the evening sky. This point in Venus's orbit was last reached on 27 March.

After this date Venus's apparent size starts to grow rapidly as does the decrease in phase. At the start of May Venus shows a 39 arcsecond disc, 24% illuminated. However, by mid-month, the apparent diameter increases to 49 arcseconds with a phase dropping to 10%. This is a stunning sight if you can catch the planet through a telescope.



▲ Enjoy it while it's there – Venus is set to disappear from the evening sky towards the end of the month

The rapid increase in apparent size coupled with the rapid decrease in phase is due to the fact that Venus is swinging around the part of its orbit closest to Earth. It also means Venus isn't far from lining up with the Sun on the Earth side of its orbit, a position known as inferior conjunction. This next occurs on 3 June and represents the planet's transition

from the evening sky to the morning sky.

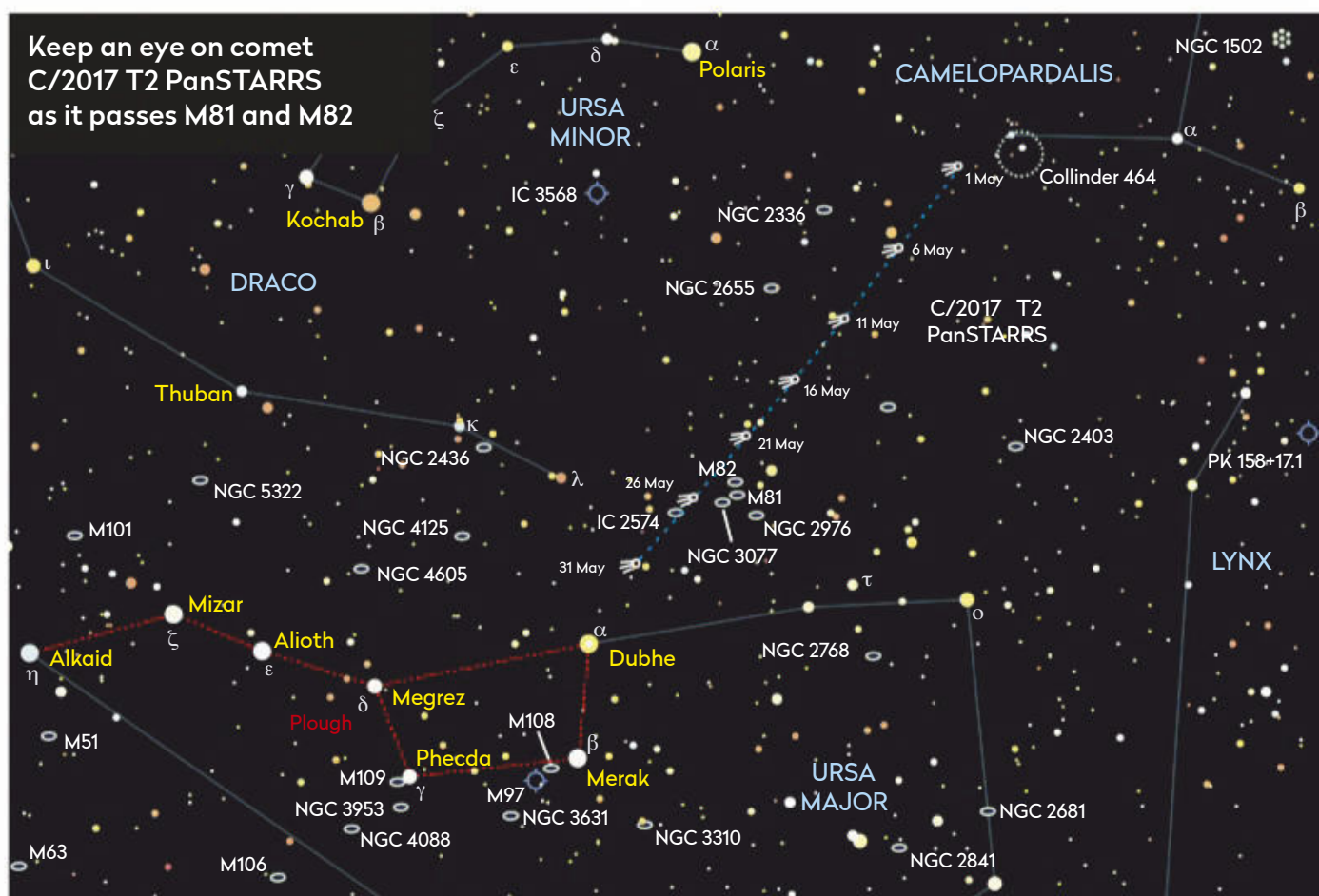
When Venus lines up with the Sun at inferior conjunction it typically passes north or south of the Sun's disc in the sky. On rare occasions it appears to pass across the Sun's face: a transit of Venus. The last of these occurred in 2012 and the next won't happen until 2117. During the next inferior conjunction on 3 June, Venus passes half-a-degree north of the Sun's centre, a condition which will place the planet just one-quarter of a degree from the Sun's northern limb; sadly, too close to observe safely.

Comet C/2017 T2 PanSTARRS shines bright

BEST TIME TO SEE: Nights of 19/20 and 20/21 May

It may not have reached naked-eye visibility as originally forecast and it may not have been the most spectacular of comets, but C/2017 T2 PanSTARRS has been a steady performer and well placed in UK skies. As well as passing through peak brightness this month, the comet passes close to a pair of galaxies in Ursa Major, M81 and M82 – Bode’s Galaxy and the Cigar Galaxy.

It begins the month at an estimated mag. +11.6 in Camelopardalis. Not the easiest constellation to identify nor navigate, the comet passes close to mag. +4.6 TYC 4530-2010-1 on the night of 4/5 May, heading east towards the northern border of Camelopardalis with Ursa Major. It crosses on the night of 17/18 May, a time when it’ll be close to the 11th magnitude galaxy IC 529. It continues southeast, passing close to mag. +5.2, 27 Ursae Majoris on the nights of 19/20 and 20/21 May, as it approaches M81 and M82. The comet’s closest approach to the galaxy pair occurs on the nights of 22/23 and 23/24 May. It’s expected to be mag. +11.5. The galaxies are listed at mag. +7.0 for M81 and +8.6 for M82.



Tracking southeast, it passes close to IC 2574, a 10th magnitude dwarf galaxy. During May, it should be visible in a small scope. It

appears small if you plan to image it.

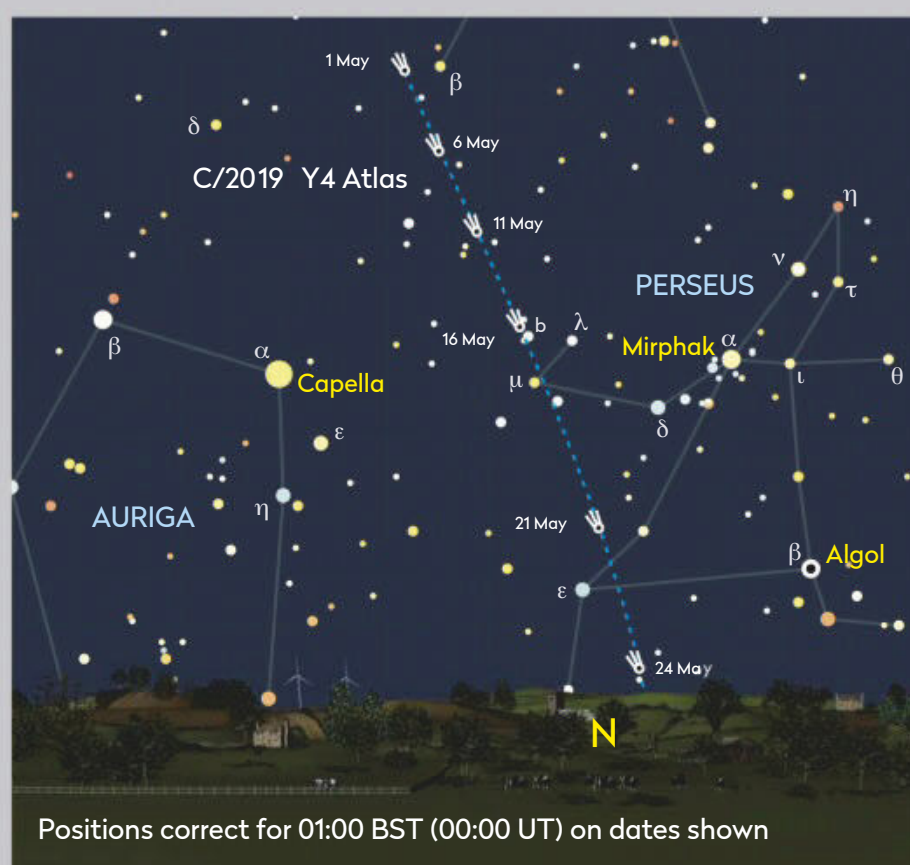
The comet’s brightness is estimated to stay above mag. +12 until July 2020.

...but will C/2019 Y4 Atlas shine brighter?

BEST TIME TO SEE: End of May

Comet C/2019 Y4 Atlas was the last comet discovery of 2019. It was discovered by the Asteroid Terrestrial-Impact Last Alert System (Atlas) on 28 December 2019 when it appeared at magnitude +19.6. In January this year, Y4 Atlas underwent an outburst, brightening by 100 times to 12th magnitude. This month, there’s a possibility that it’ll become bright enough to be seen with the naked eye although, as is fairly typical with comets, this will occur as it’s approaching perihelion and badly positioned in the sky.

Y4 Atlas has an orbit not dissimilar to that of the Great comet of 1844 (C/1844 Y1). From the UK it’ll be best placed in the middle of May, passing closest to Earth on 23 May by a distance of 117 million km. If it follows its current brightness trend, it should appear around seventh magnitude on 1 May, approaching fourth magnitude mid-month. Throughout this period the comet will head south from Camelopardalis into Perseus, placing it in a low northern part of the sky for UK viewing. At 01:00 BST (00:00 UT) on 15 May it lies close to Mu (μ), Lambda (λ) and b Persei. Despite being low, the comet will be circumpolar for most of May, giving an opportunity to track it from evening into the morning. As ever with comets, their brightness can go down or occasionally up relative to predictions.



▲ Comet C/2019 Y4 moves down from Camelopardalis to Perseus

THE PLANETS

Our celestial neighbourhood in May



▲ Follow the course of brilliant Venus over the month of May, as it evolves from being visible in the evening for 1.5 hours to just 30 minutes

PICK OF THE MONTH

Venus

Best time to see: 1 May, approximately 30 minutes after sunset

Altitude: 27°

Location: Taurus

Direction: Southeast

Features: Phase, subtle markings

Recommended equipment: 75mm or larger

We are now entering an important and beautiful time for the planet Venus. As it swings around the part of its orbit closest to Earth, its appearance both in the sky and through the eyepiece will change rapidly. Inferior conjunction – when the planet appears to line up with the Sun as it transitions from the evening sky to the morning sky – occurs on 3 June. If you’ve become used to the sight of this blazing world over in the west after sunset, this is all about to change.

At the start of May, Venus appears to shine at mag. –4.4, sets almost four hours after the Sun and through the eyepiece presents a 39 arcsecond disc, a beautiful

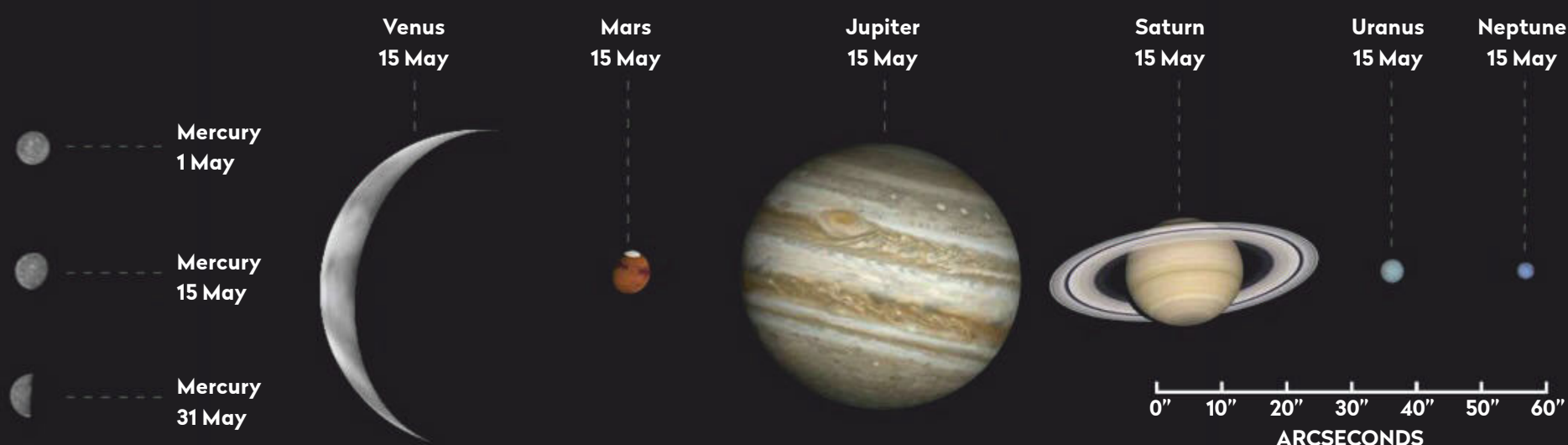
crescent 24% illuminated. However, the light evenings only allow 1.5 hours of viewing against a truly dark sky on 1 May.

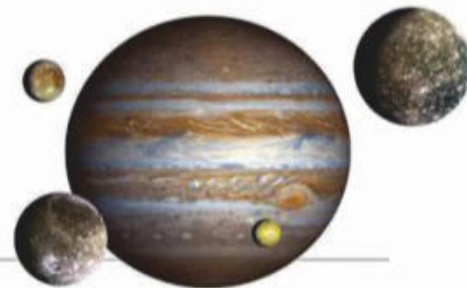
By the end of the month Venus will appear to shine at mag. –3.7 and set just 30 minutes after sunset. Through a telescope it will appear almost one arcminute across but a delicate, slender crescent less than 1% illuminated on 31 May.

The transition from its appearance on 1 May through to 31 May will be fascinating to watch. The crescent phases of Venus are a sight to behold and quite beautiful. However, there is also a hint of sadness at the departure of this spectacular planet from our evening skies after so long.

The planets in May

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 22 May, 50 minutes after sunset

Altitude: 7°

Location: Taurus

Direction: Northwest

Mercury reaches superior conjunction on 4 May, after which it re-emerges into the evening sky. And it does this in spectacular fashion, being well placed after sunset and appearing bright. On 9 May it shines at mag. -1.7 and sets 40 minutes after the Sun. This should make it easy to see, but if you're in doubt about whether you have, it appears close to Venus on the 21st and 22nd and this can be used as a guide.

Mercury appears at mag. -0.6 on 21 May and is separated from mag. -4.1 Venus by 1.4° in the evening twilight. On 22 May, mag. -0.5 Mercury is 1.3° from Venus. The best strategy is to attempt to locate Venus after sunset. It's so bright, it's normally simple to pick it up as soon as the Sun has gone below the horizon or even with the Sun up if the sky's clear.

Mercury continues to dim over May, but its position remains favourable. A telescopic view on 9 May reveals a tiny disc 5 arcseconds across and almost fully lit at 97% illumination. On 22 May, when it has a close encounter with Venus, it appears 6 arcseconds across and 67% lit in a scope. By May's end, it appears 7 arcseconds across and 45% lit.

On the 23rd a 1%-illuminated waxing crescent Moon sits 6.3° to the south of Venus and Mercury. The Moon sets just less than an hour after the Sun and will be a tough spot in the evening twilight. A better opportunity occurs on the next evening when the now 4%-lit waxing crescent Moon lies 5° to the southeast of mag. -0.3 Mercury. From the UK this places the Moon to its left.

Mars

Best time to see:

31 May 03:00-03:30 BST (02:00-02:30 UT)

Altitude: 9°

Location: Aquarius

Direction: East-southeast

Mars is brightening and telescopically its apparent size is increasing. However, it's still a challenge because its apparent motion against the stars and location in the sky is hindering views. This will change as we move towards opposition in October but for now, Mars remains low in the morning sky. On 31 May, it shines at mag. +0.0, a brightness increase of 1.4x over its appearance on the 1st. Through the eyepiece, Mars is 9 arcseconds across and appears 84% illuminated on 31 May. A waning crescent Moon lies 3.3° to its south on 15 May.

Jupiter

Best time to see: 31 May from 02:00 BST (01:00 UT)

Altitude: 10°

Location: Sagittarius

Direction: Southeast

Jupiter is a bright morning planet which appears close to dimmer Saturn. On 1 May it shines at mag. -2.2, brightening to -2.4 by May's end. A 73%-lit waning gibbous Moon lies near on the morning of 12 May.

Saturn

Best time to see: 31 May, from 02:00 BST (01:00 UT)

Altitude: 9°

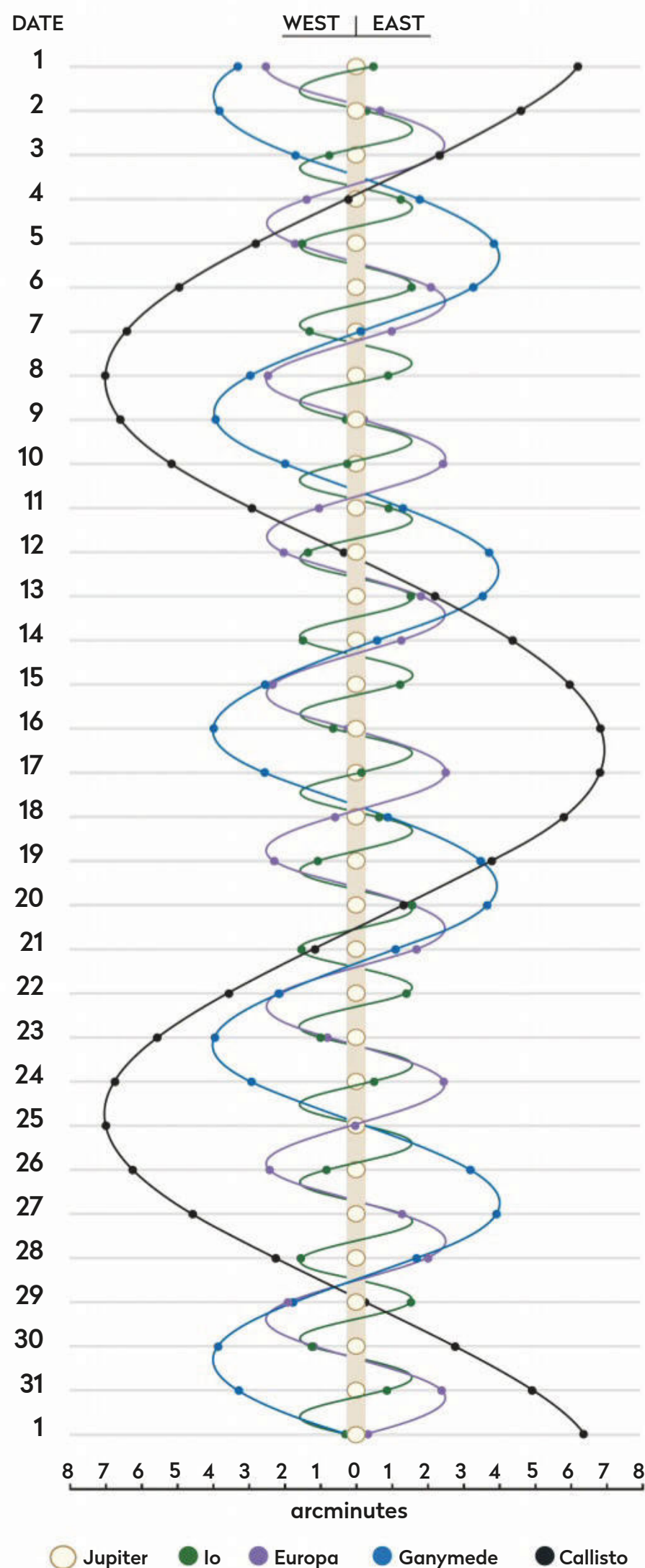
Location: Capricornus

Direction: Southeast

Saturn is a morning object, outshone by Jupiter to the west. The Moon appears nearby on the mornings of 12 and 13 May. It brightens slightly from +0.8 to +0.7 over the month.

JUPITER'S MOONS: MAY

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



More **ONLINE**

Print out observing forms for recording planetary events

THE NIGHT SKY – MAY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- ★ **Arcturus** STAR NAME
- PERSEUS** CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- ASTERISM
- PLANET
- QUASAR
- STAR BRIGHTNESS:**
 - MAG. 0 & BRIGHTER
 - MAG. +1
 - MAG. +2
 - MAG. +3
 - MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 May at 01:00 BST

15 May at 00:00 BST

31 May at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in May*



Date	Sunrise	Sunset
1 May 2020	05:35 BST	20:41 BST
11 May 2020	05:16 BST	20:58 BST
21 May 2020	05:01 BST	21:14 BST
31 May 2020	04:49 BST	21:28 BST

Moonrise in May*

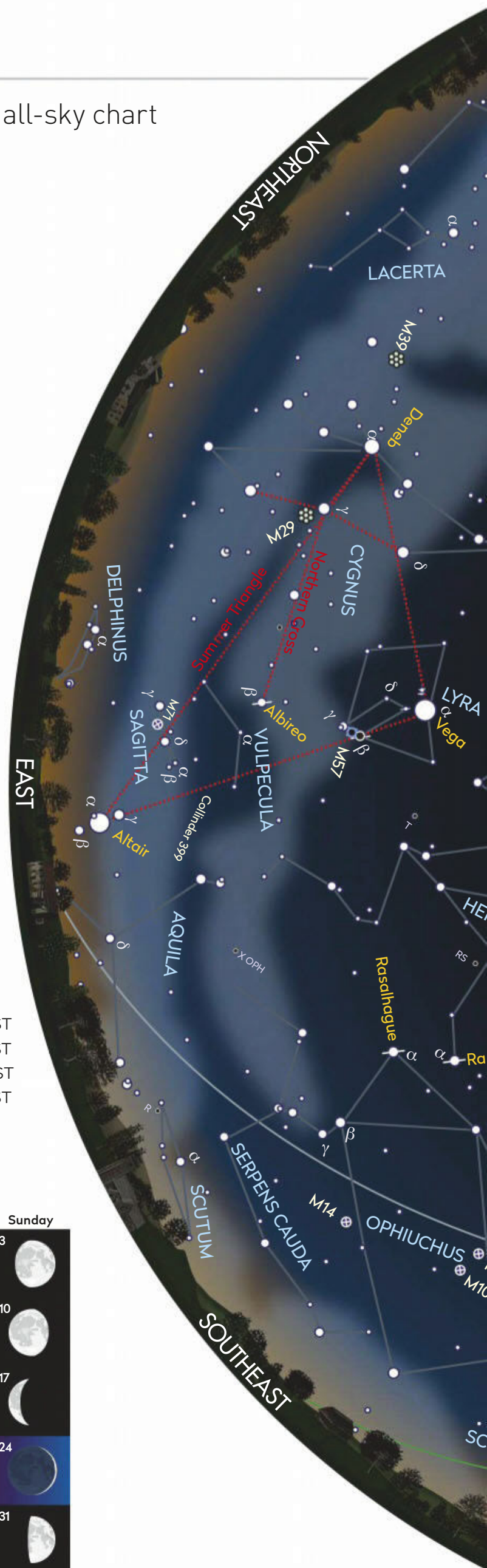


Moonrise times	
1 May 2020, 11:15 BST	17 May 2020, 02:56 BST
5 May 2020, 17:01 BST	21 May 2020, 03:53 BST
9 May 2020, 22:49 BST	25 May 2020, 05:47 BST
13 May 2020, 01:31 BST	29 May 2020, 10:23 BST

*Times correct for the centre of the UK

Lunar phases in May

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

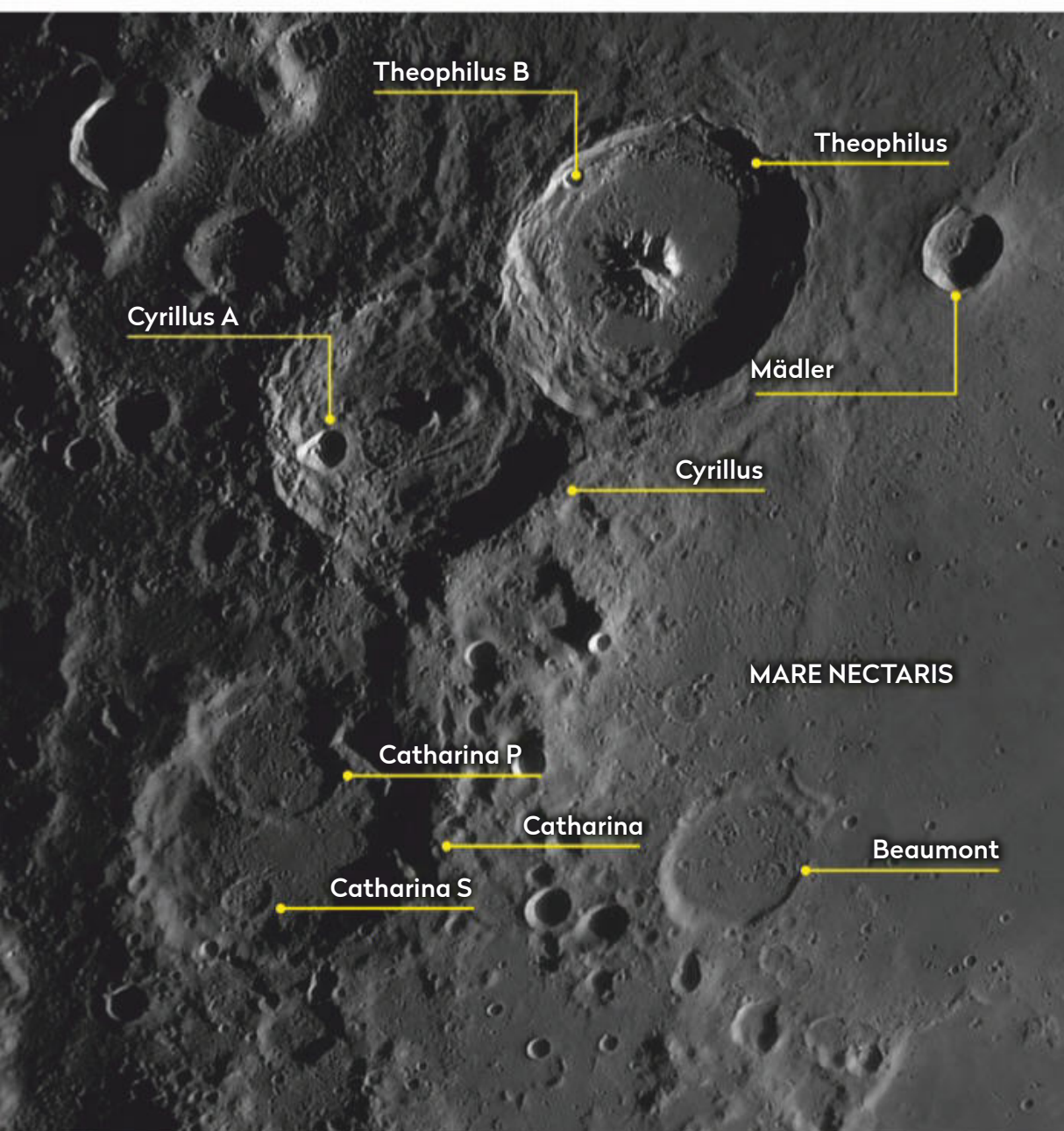




MORE ONLINE

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide



All three craters are about the same size, but visually they couldn't be more different

3.85 and 3.92 billion years ago. They show their age too. Looking at **Catharina** first, this crater's rim is rough and heavily eroded. Any rim terraces have disappeared over time although there is a hint of their existence toward the western section. The crater floor is flat with no central peak. Being ancient it's of little wonder that there are features overlaid on Catharina's floor. The northern third of Catharina is overlaid by the 46km crater **Catharina P**. This is another eroded feature notable for the way its weak rim runs over, but doesn't completely break that of Catharina below. To the south is what could be called a ghost crater within Catharina in the form of 16km **Catharina S**. All that remains of this crater is a single outer rim. Catharina itself is around 3km deep.

The southern edge of the rim of **Cyrillus** lies 50km to the north of the northern rim of Catharina. Like Catharina, Cyrillus is ancient but perhaps has stood the test of time a little better than its southern neighbour. Cyrillus's eroded rim is easier to pick out than Catharina's, Cyrillus having a depth of 3.6km. Here the floor isn't completely flat with three central mountains rising to a height of around 1km. A series of cracks, most notable in the southeast half of the crater, also disrupt the floor. The teardrop shape of 17km **Cyrillus A** can be seen close to the west-southwest rim.

The crowning glory of the trio is **Theophilus** to the north. This is a much younger feature than Catharina and Cyrillus, evidenced by the sharper appearance of Theophilus and more obviously by the way it cuts into the northeastern part of Cyrillus's rim, overlaying the older crater. Theophilus is a magnificent and classic example of a crater, its outer ramparts leading up to a sharp crater rim. Continuing over the rim edge, here you'll meet intricate terraces which present ever-changing shadow detail when the lunar terminator is near. The terraces lead down to a flat floor which surrounds a magnificent central mountain complex. There are four distinct peaks here rising to a height of 1.4km above the surrounding floor. These have an almost symmetrical appearance to them, a deep valley dividing two pairs of large and small mountains.

Youthful Theophilus has an age estimated to be between 1.1 and 3.2 billion years. This is emphasised by the lack of overlaying craters. The only interloper within Theophilus is 8km **Theophilus B** embedded in the main crater's northwest rim. Theophilus itself has a depth around 4.2 km.

Theophilus, Cyrillus and Catharina

Type: Crater trio

Size: 90 x 31km

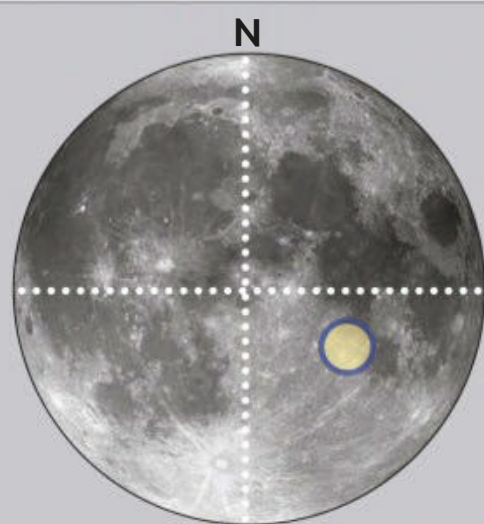
Longitude/latitude:

24.1° E, 13.3° S (Cyrillus)

Age: 1.1–3.9 billion years

Best time to see: Five days after new Moon (27–28 May) and four days after full Moon (12–13 May)

Minimum equipment: 10x binoculars



Three distinctive craters border the western edge of **Mare Nectaris**; 101km **Theophilus**, 98km **Cyrillus** and 101km **Catharina**. All three are more or less the same size, but visually they couldn't be more different.

Sometimes cited as a crater trio, this label is in name only as there is no direct physical connection between the three apart from where overlapping has occurred. As a trio they are fascinating to observe through the eyepiece and also to image, representing similar-sized features formed over a huge span of time.

Catharina in the south and Cyrillus in the middle are the elders, having formed sometime between

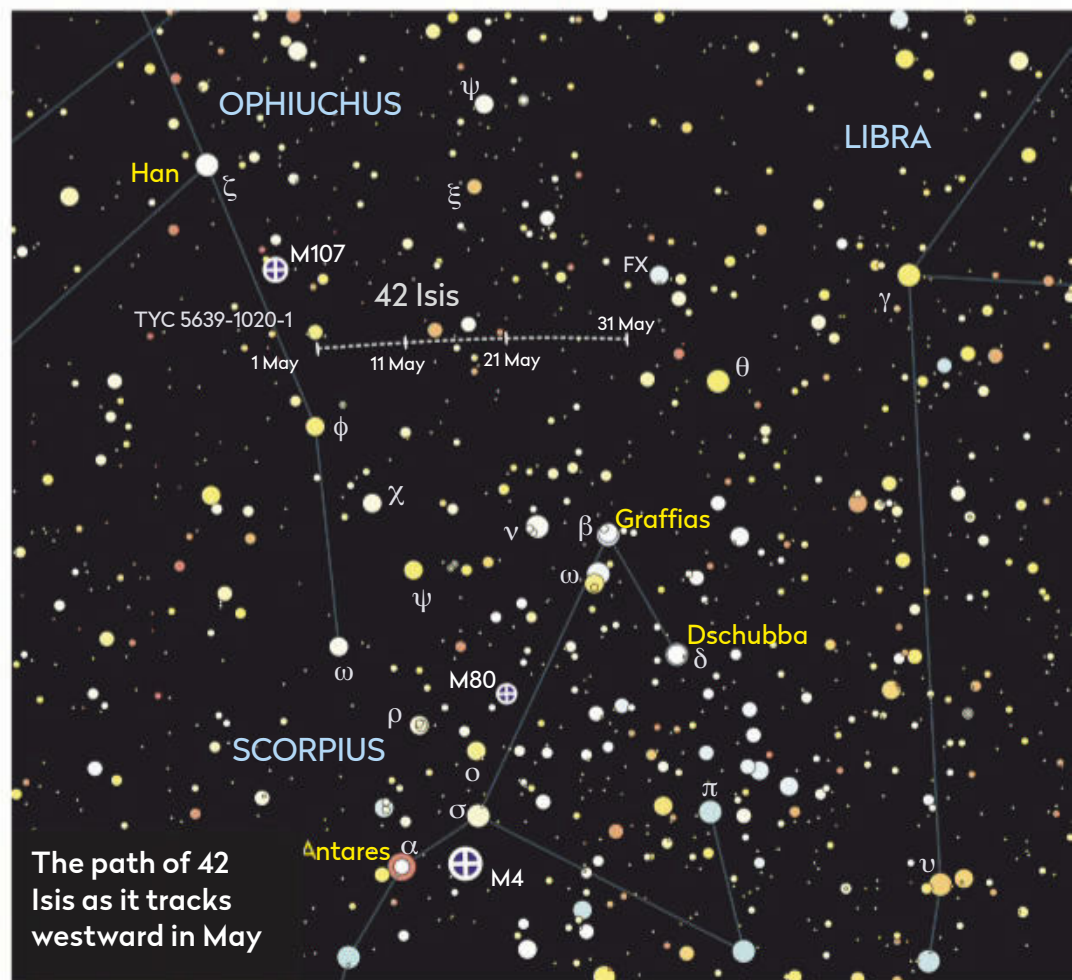
COMETS AND ASTEROIDS

Minor planet 42 Isis reaches opposition in Scorpius towards the month's end

Minor planet 42 Isis reaches opposition on 23 May when it appears a little brighter than 10th magnitude in the constellation of Scorpius, in the region of sky to the north of the Scorpion's claws. Its monthly journey begins in Ophiuchus less than half a degree to the south of mag. +5.7 TYC 5639-1020-1, which itself lies a little over 2° north of mag. +4.3 Phi (φ) Ophiuchi and 1.5° south-southwest of the mag. +7.8 globular cluster M107. On 1 May, 42 Isis shines at mag. +10.7, brightening toward opposition as it tracks west. It crosses the border into Scorpius on 10 May, creeping into Libra on the 31st. At opposition, on the 23rd, it reaches mag. +9.8 and is suited for small-scope viewing. By the 31st it will have faded to mag. +10.0.

42 Isis is a substantial body, measuring 103km in diameter. It was discovered by Norman Pogson, a comet hunter who introduced the mathematical scale known as Pogson's ratio which described the 2.512 (square root of five) brightness difference between two successive magnitudes. This was his first asteroid discovery and is named in honour of his daughter, Elizabeth Isis Pogson. Isis was the Egyptian god of magic, fertility and motherhood.

It is a main belt asteroid with an orbit that extends out as far as 2.986AU from the Sun and as close as 1.898AU. Isis is a siliceous or S-type asteroid which means it is of mineralogical composition – ie, stony. It takes 42 Isis 3.82 years to complete one orbit.



STAR OF THE MONTH

Cor Caroli, a star named in honour of King Charles II

Cor Caroli (Alpha (α) Canum Venaticorum) is the brightest star in the small, but deep-sky rich constellation of Canes Venatici, the Hunting Dogs. Shining at mag. +2.9, it is complemented by mag. +4.2 Chara (Beta (β) Canum Venaticorum). On charts, Canes Venatici is typically depicted as a single line joining both stars together.

The name Cor Caroli literally means "Charles's Heart" a name bestowed on it by Edmund Halley to honour King Charles II. It's easy to locate because it sits to the south of the handle of the Plough asterism. If you view the handle of the plough as part of a circle, Cor Caroli marks the approximate position of the centre of the circle.

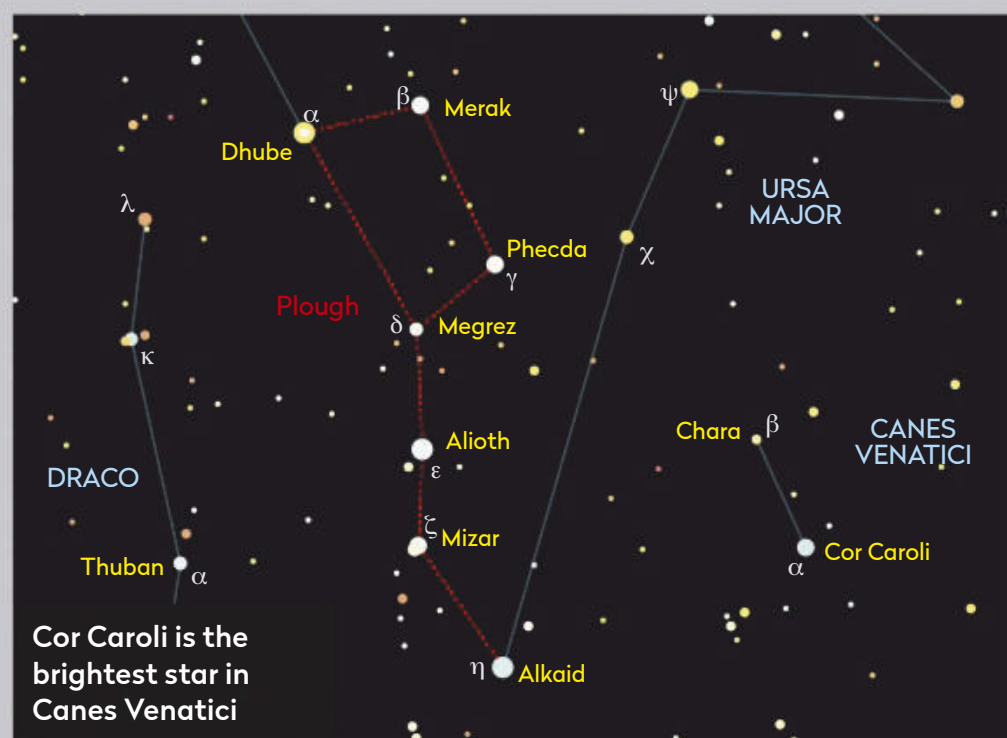
Through a telescope, Cor Caroli appears double. Alpha-2 (α²) Canum Venaticorum is the brighter component showing variability over a 5.5-day period between mag. +2.8 and +3.0. Alpha-1 (α¹) Canum Venaticorum has a visual magnitude of +5.6. The

Alpha-2 and Alpha-1 are labelled this way because the western, and in this case dimmer, component is numbered first. The apparent separation between both stars is 19.6 arcseconds.

Alpha-2 is a special type of star that shows a peculiar composition and has a strong magnetic field estimated to be around 5,000x stronger than Earth's. The Sun, by comparison, has a field, which is just a few times stronger. Alpha-2 is a dwarf star of spectral type A0pSiEuHg. This means it's a white star ('A0') with a peculiar spectrum ('p') showing strong lines for elements silicon, europium and

mercury ('SiEuHg'). Alpha-2's strong magnetic field causes extreme examples of sunspots on the star's photosphere and these swing into and out of view causing variations in its apparent brightness.

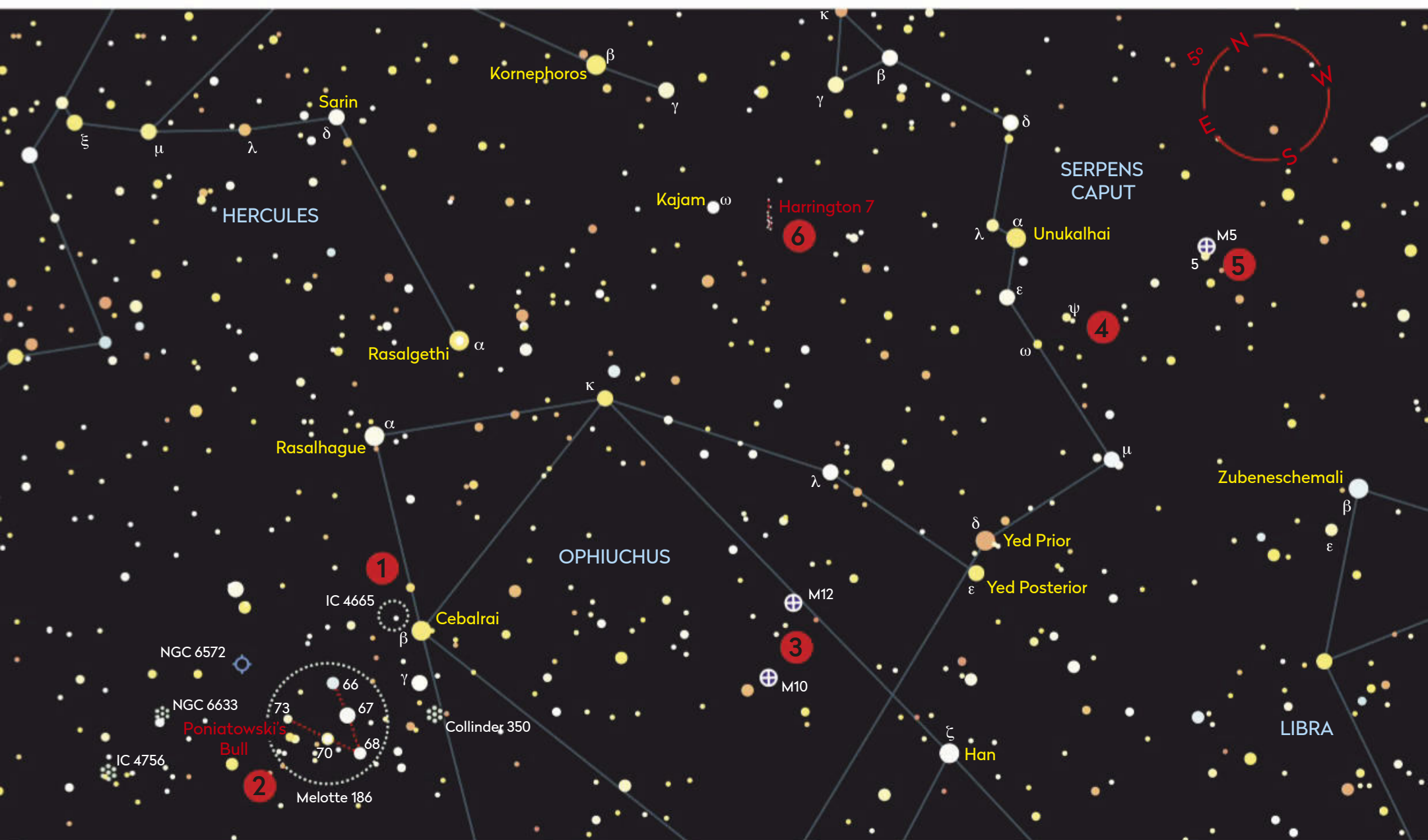
Alpha-1 has a spectral type of F0V, which means it's a yellow-white main sequence dwarf type star. It's also rich in iron. The stars are separated by around 675 AU and orbit one another over a period of around 8,300 years.



BINOCULAR TOUR

With Steve Tonkin

The Summer Beehive creates a buzz as it leads this month's wide-field treasures



1. The Summer Beehive

10x 50 Let's begin with a cluster that literally welcomes you to late spring skies. The Summer Beehive, IC 4665, is in the same field of view as Cebalrai (Beta (β) Ophiuchi) and contains curves of brighter stars that, rotated 90° anti-clockwise, form the word "HI". This young open cluster is a pleasure in binoculars of any size and you should be able to resolve at least a dozen stars with your 10x50s. ☐ **SEEN IT**

2. Poniatowski's Bull

10x 50 We'll continue with an easy object that seems to be made for binoculars – M186. It is centred on the 4th magnitude star 67 Ophiuchi and includes a prominent 'vee shape' made by 66, 67, 68, 70 and 73 Ophiuchi. This vee shape is reminiscent of the Hyades cluster in Taurus, a similarity that inspired the 18th-century Lithuanian astronomer, Marcin Odlanicki Poczobutt, to propose it as a new constellation, Taurus Poniatovii (Poniatowski's Bull). ☐ **SEEN IT**

3. M10 and M12

10x 50 M12 is very close to the northeast apex of an equilateral triangle that has Yed Prior (Delta (δ) Ophiuchi) and Zeta (ζ) Ophiuchi as its other apexes; M10 is a little more than 3° southeast of it. They offer a useful demonstration of averted vision: if you mount your binoculars, you will find that when you direct your gaze to one, the other brightens. This will also show that M10 has a much more distinct core. ☐ **SEEN IT**

4. Psi (ψ) Serpentis

10x 50 Psi (ψ) Serpentis is easy to locate as it is due south of Unukulhai (Alpha (α) Serpentis) and west of Omega (ω) Serpentis. Initially you'll see a pair of yellow stars 6 arcminutes apart but, as you look more carefully, you should be able to make out a third, much fainter, star mid-way between them. This is a line-of-sight grouping; the brightest star is much closer than the others and is only 5% as luminous. ☐ **SEEN IT**

5. M5

15x 70 Our next target is another globular cluster, M5, which is 6° due west of ψ Ser and next to a 5th magnitude star, 5 Serpentis. This 24,500 lightyear-distant cluster is one of the largest known globulars. It spans 165 lightyears and is estimated to house close to half a million stars. These are metal-poor Population-II stars that formed about 13 billion years ago, at the same time as our Galaxy. ☐ **SEEN IT**

6. Harrington 7

15x 70 Our next target was discovered by well-known binocular aficionado, Phil Harrington. Identify Kajam (Omega (ω) Herculis) and pan 2° west to a golden 8th magnitude star, part of a 1.3°-long chain of fainter stars that runs north to south. It is pareidolia, where familiar pictures are seen as random patterns. Harrington describes it as a zigzag. What do you see? ☐ **SEEN IT**

☒ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

Can you solve the mystery of the clair-obscur effect known as Plato's Hook?

This month's challenge is to observe an intriguing clair-obscur effect known as Plato's Hook. It was famously recorded by Patrick Moore and HP Wilkins on the night of 3 April 1952, although there's some controversy surrounding the precise timing of the observation. The hook refers to the shape of the shadow cast by one of the peaks around Plato's rim, the so-called 'gamma peak'. At certain times when morning light has flooded most of the crater's interior, as the eastern rim shadow is retreating back towards the rim, the gamma peak casts its pointed shadow across Plato's floor.

What Moore and Wilkins reported while using the 33-inch refractor in Meudon, Paris, was a curiosity with this shadow. It looks curved where you'd normally expect it to look straight. As such it gives the appearance of a hook rather than the more triangular, sharp

tooth shape you might expect. This begs the question what is going on?

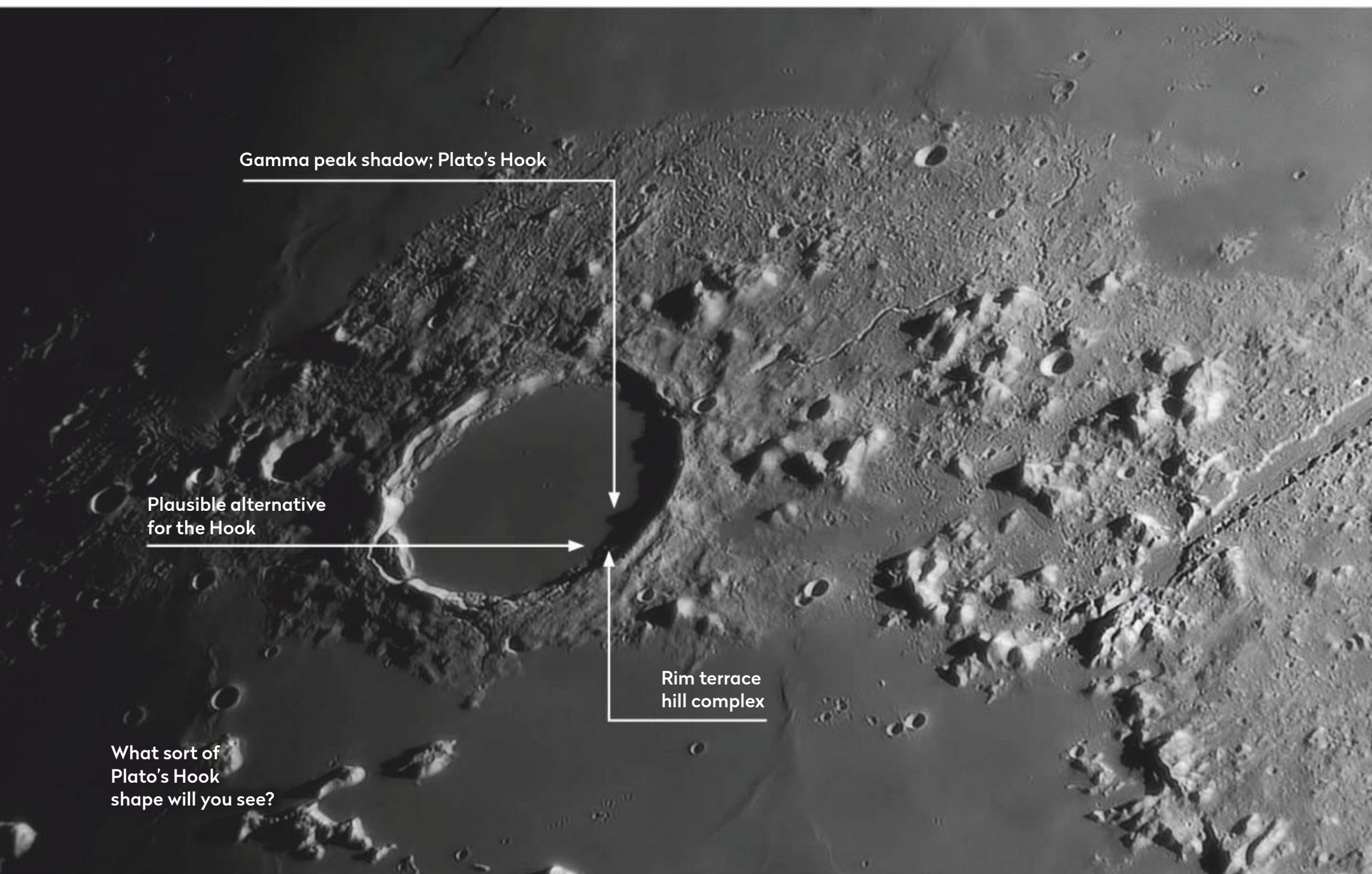
One theory cast into the pot suggested the shadow was falling onto a low-lying hill complex and as it falls down the hill, so it takes on the curving shape of the surface. This seems fairly plausible except that some interesting simulations made by an Italian team using computer and Plasticine models suggest a) the gamma peak never exhibits curvature as shown in Moore and Wilkin's drawings and b) the shadow cannot appear where the hook is reported in drawings.

The Italian explanation seems more plausible than the gamma peak shadow falling onto rolling hills. Their suggestion is that the curved shadow is formed where the main rim shadow is interrupted in the southeast by a complex set of hills within Plato's rim terraces. Looking back at our own archives, we have one shot which is

illuminated this way and, well, it's not exactly clear.

The only way to verify what's happening is to observe it yourself. Indeed, modern high-resolution imaging should be able to put this topic to rest completely. However, in order to do this the terminator needs to be in the correct place, the seeing reasonably good and the weather clear. Plato's Hook should be visible during the day on 1 May, around 14:30 BST (13:30 UT), or better placed on 1 June around 00:49 BST (23:49 UT on 31 May). However, with the disagreements stated an extended observation time would be appropriate to see how things develop.

We don't know what you'll see or what you'll record and that's fascinating. Astronomy isn't always about being told what you'll see. This is a real observation that could potentially solve a mystery which has endured for many decades.



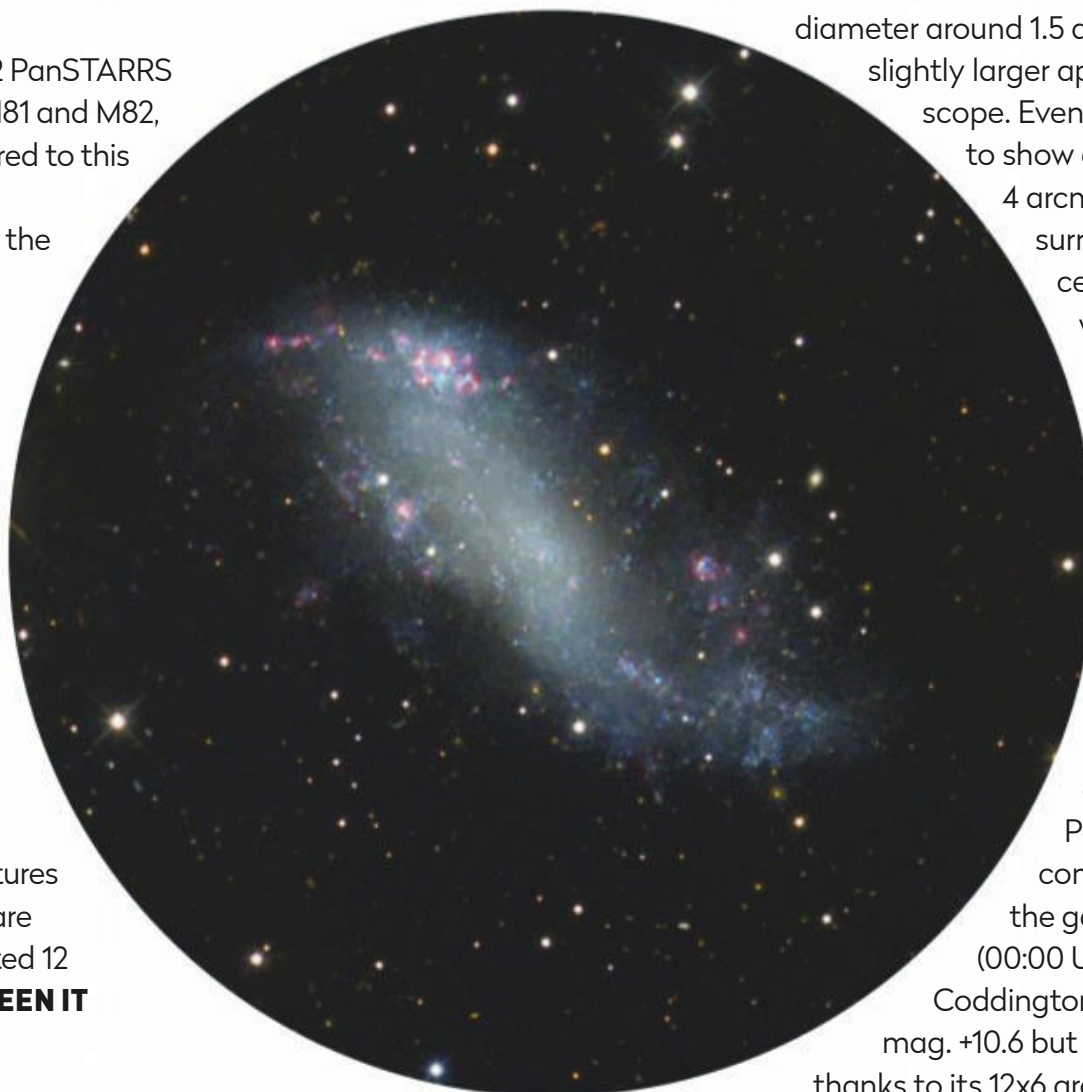
DEEP-SKY TOUR

We follow the trail of Comet C/2017 T2 PanSTARRS past galaxies great and small

1 M81



Comet C/2017 T2 PanSTARRS passes close to M81 and M82, so our Deep-Sky Tour is geared to this area of sky. Locate them by extending a diagonal across the pan of the Saucepan from Phecda (Gamma (γ) Ursae Majoris) through Dubhe (Alpha (α) Ursae Majoris) for the same distance again. M81 and M82 are 2° to the north of the point you reach. Bode's Galaxy, M81, is a bright spiral galaxy. It shines at mag. +7.8 and appears as a 20×11 arcminute glowing oval. The core is bright, showing good condensation, but the outer spiral arms need larger apertures to see convincingly as they are thin and spindly. M81 is located 12 million lightyears away. **SEEN IT**



diameter around 1.5 arcminutes. A similar, albeit slightly larger appearance greets a 250mm scope. Even larger apertures will begin to show a weak, larger glow about 4 arcminutes across which surrounds the 2-arcminute central condensation and wide core. **SEEN IT**

2 M82



Despite being dimmer than M81, 9th magnitude M82 is easy to find because it lies 37 arcminutes to the north of M81. M82 is known as the Cigar Galaxy because of its distinctive shape. Being so close to M81, it's easy to get both objects into the same low-power field of view. When you do, the contrast in shape is quite stunning. M82 is an irregular galaxy with high star-formation activity and a prototype for a class of starburst galaxies. Smaller apertures reveal a view which looks like a regular sideways-on spiral. With larger apertures, the core begins to show a mottled appearance with bright knots separated by darker dust lanes. M82 is a member of the M81 group and shares its neighbour's distance of 12 million lightyears. **SEEN IT**

▲ **Coddington's Nebula, IC 2574.** A study has revealed that 90% of its mass is tied up in dark matter

A study of the galaxy reveals that 90% of its mass is tied up in dark matter. Locate Coddington's Nebula 2.9° east and half a degree south of M82. **SEEN IT**

3 NGC 3077



Our next target is NGC 3077, a disturbed elliptical galaxy which is also a member of the M81 group. Again, this galaxy is easy to locate as it's in the same field as M81 and M82, marking the eastern vertex of a right-angled triangle formed with M81 and M82, M81 sitting at the right angle. NGC 3077 appears as a circular glow through a 150mm scope, much smaller than M81 or M82, with an apparent

5 NGC 2976



NGC 2976 is another unusual looking galaxy, located 1.3° to the south of M81. Although it's classed as an unbarred spiral galaxy, mag. +10.8 NGC 2976's spiral arms are difficult, if not impossible to see. A small scope will show it as a weak glow 3 arcminutes across, but having low surface brightness and no evidence of any definite core. A 300mm scope at 200x shows a glowing ellipse with a mottled, uneven texture. Averted vision will show several brighter patches within the galaxy's irregular border. These are evident on the northwest side. This object is another member of the M81 group and is 11.6 million lightyears away. It was discovered by William Herschel in 1801. **SEEN IT**

6 NGC 2985



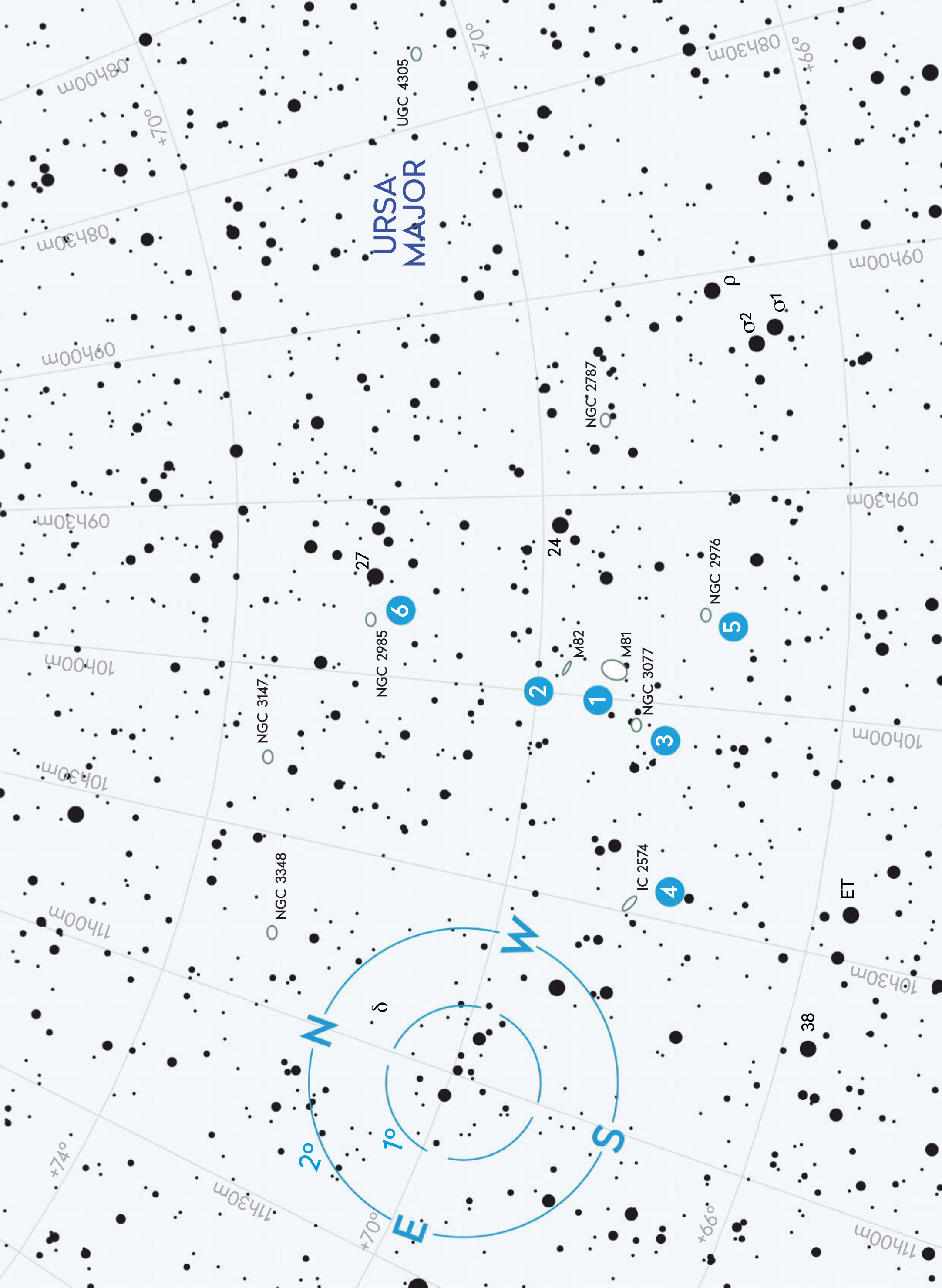
Next is NGC 2985, the brightest member of the NGC 2985 group. It shines at mag. +10.4 and is located 3.2° north and 28 arcminutes west of M81. A 150mm scope reveals a fuzzy glow about 1 arcminute across. Its nucleus appears stellar through small instruments. A mag. +12.5 star sits 1 arcminute from the nucleus on the eastern side. This is a marker because with a 250mm instrument the galaxy's outer halo, formed from a complex wrapping of tightly wound spiral arms, extends beyond this star to present a halo 2 arcminutes across. **SEEN IT**

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.



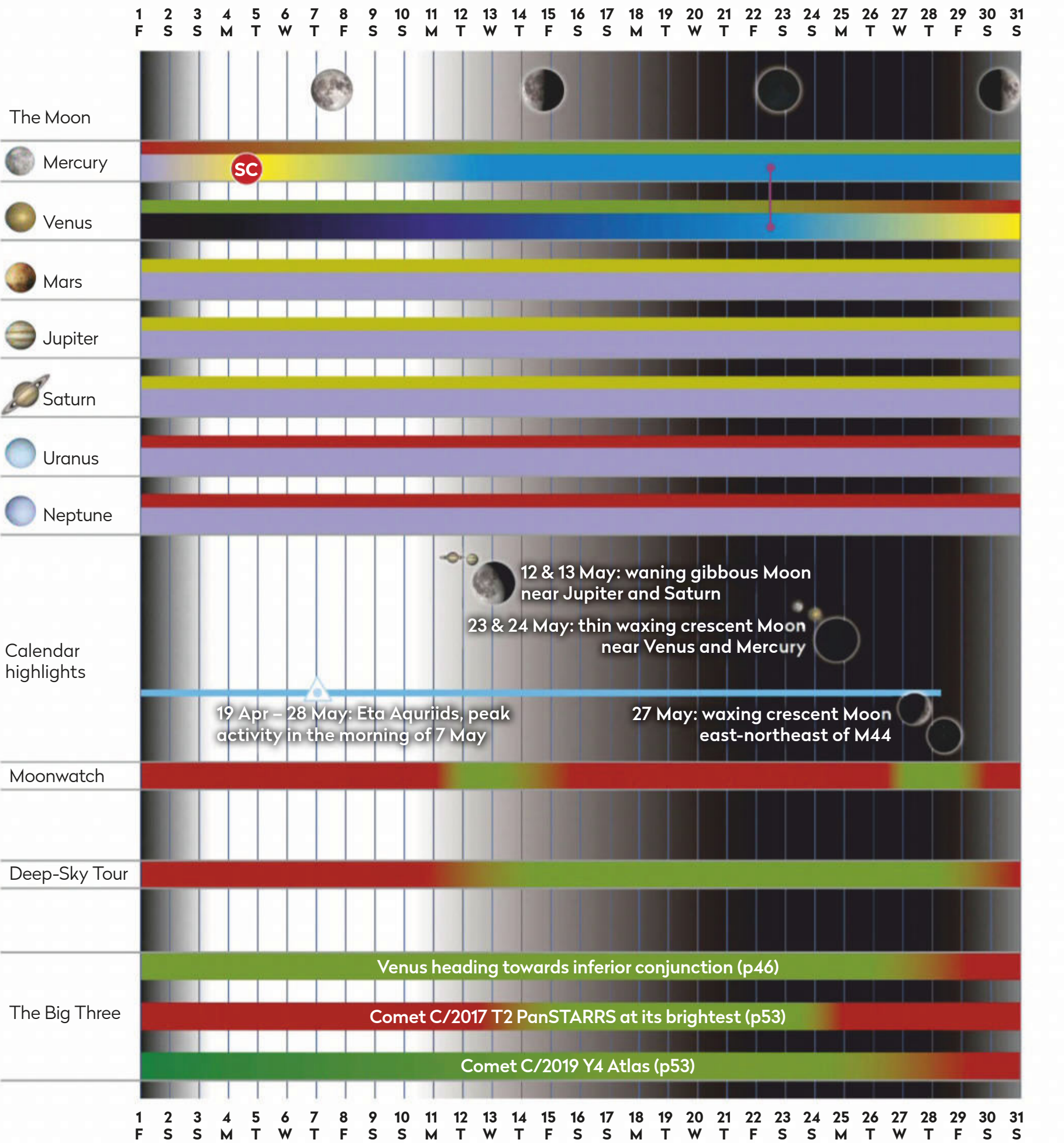
More
ONLINE

Print out this chart and take an automated Go-To tour. See page 5 for instructions.



AT A GLANCE

How the Sky Guide events will appear in May



KEY

Observability



Best viewed



Sky brightness during lunar phases



- IC** Inferior conjunction (Mercury & Venus only)
- SC** Superior conjunction
- OP** Planet at opposition
- Meteor radiant peak
- Planets in conjunction
- Full Moon
- First quarter
- Last quarter
- New Moon



HIGHLIGHTS OF HUBBLE

◀ Seeing Red

CAPTURED: 26 JUNE 2001

The rusty hue of the Martian surface is revealed in vivid detail in this 2001 image. It was captured by Hubble when Mars was about 68 million km from Earth, its closest approach since 1988. As well as turbulent dust storms, white clouds of water ice can be seen.

▼ A stellar hatchery

RELEASED: 23 APRIL 2015

Released to celebrate Hubble's 25th anniversary, this image of the star cluster Westerlund 2 reveals a vast breeding ground of stars located 20,000 lightyears away in the constellation of Carina. It reveals a breathtaking palette of colours. 🌌



The Sky at Night

800th episode special

A passion for SPACE



Dr Ezzy Pearson is BBC Sky at Night Magazine's news editor. She gained her PhD in extragalactic astronomy at Cardiff University

The Sky at Night was inspired by Patrick Moore's love of the night sky. As the show celebrates its 800th episode, **Ezzy Pearson** takes a look at other astronomers who've followed his example

On 24 April 1957, *The Sky at Night* aired its first ever episode. The show's presenter, the late Sir Patrick Moore, had waged a one man letter-writing campaign with the BBC for months to produce an astronomy show introducing the wonders of the night sky. Faced with Moore's unwavering zeal for

astronomy, the BBC gave him his show. Since then, *The Sky at Night* has gone on to become one of the longest-running television shows in the world and is now celebrating its 800th episode. Here, we take a look at some equally enthusiastic astronomers around the UK, whose own love of space has led them to work on their own passion projects encouraging people to look up at the night sky.



Meteor hunting

A UK meteor network evolved from **Richard Kacerek's** desire to capture one



Richard Kacerek is one of the founders of the UK Meteor Observation Network, or UKMON, (ukmeteornetwork.co.uk) – a group of amateur meteor hunters that use video cameras to hunt down meteors streaking across the night sky. It was, however, a group he'd never intended to found.

"We didn't mean to start a network – it was completely by accident," says Kacerek. "I just wanted to find meteors. When I first got involved with meteor detection in 2012, it was just my camera in the UK and one in France."



▲ **Keeping watch:** UKMON can now pick up multiple detections of a single meteor

He soon began giving talks at local astronomy societies, helping others set up their own cameras. Before long, he was working with dozens of other people to search the night sky for meteors.

"People like the fact you can turn on the camera in the evening and then come back in the morning to see what you've found," says Kacerek. "Sometimes when you come to look at what you've captured there's an absolutely massive fireball. That's a great moment because it explodes in the media. We get to be part of the news. It's like astrofishing – you don't know what you're going to catch."

With so many people taking part, UKMON is usually able to pick up multiple detections of a single meteor and accurately gauge its position, increasing the scientific usefulness of detections. Yet while the team collaborates with institutes such as the University of Bath and the International Meteor Organisation, science isn't its primary aim.

"It was a hobby that turned into a citizen science project, but it's still meant to be a hobby. If you have fun along the way that's what counts. That's our fundamental policy," says Kacerek.

For the last few years, UKMON has been working with the Natural History Museum to get cameras into schools, as well as onto the museum itself, as the meteor hunt is a great way to get children interested in astronomy and science in general.

"The reason why I started with astronomy was to look up and enjoy the night sky, an experience which nowadays is becoming scarce. Now with light pollution, I think this generation is losing a lot," says Kacerek.

Fortunately, meteor detection cameras can work remotely and can be set up on roofs or in awkward corners, pointing away from the worst of the light pollution to give astronomers a clear night sky view.

"If you want to record meteors you should join us," says Kacerek. "Good telescopes are expensive, but for meteor observing I could get everything I needed for just £500. I've never looked back." ►



▲ **To start meteor hunting all you need is a camera and a computer**



▲ **Cameras can cover an extremely wide area of sky**



▲ **UKMON members gather to discuss the meteor network**

Interview: Kerry Williams

A keen amateur astronomer explains how she uses her hobby to inspire a local Scout Group to learn about the night sky and earn their Space badges



"I've **always** loved **space** – I've got a **telescope**, look **at** the stars and I watch *The Sky at Night* whenever it's on TV. I'm not an **astronomical** genius, but it's a hobby that I'm **passionate** about. When my son was in Beavers, as **part** of the local Scout Group, a **few years ago**, the organisers asked if I'd go along

and do a space night for them. They're always looking for people to do different evenings to make it as exciting as possible for them each week – the more exciting it is, the more badges they earn and the more they learn.

"The Beavers badge requires them to know all the names and the order of the planets so I brought in a pumpkin for the Sun and then smaller fruits for the other planets. Mercury was just a peppercorn. Then I had them guess which one represented each planet and put them in order and spread them out across the hall to learn about the distances between them.

"With the Moon landing anniversaries last year, the Cubs leader asked me to do a night for them. You can complete the Beavers Space badge in an hour, but the Cubs goes over two nights. First we made

a model of the Solar System using donated polystyrene balls and kebab sticks. There was enough for each child to take one home. The next day my son came home saying some of his friends had brought their models into school because they were really pleased with them. I thought that

was amazing; they were pleased and that pleased me.

"The second evening took a while to get going because it involved going out and actually observing. We had to wait

for the right weather. We had different stations for them to move around every 10 minutes. One had a telescope, another was for them to observe with just their eyes, while another was for using tables and apps to look around. As a result they got to observe the sky in different ways.

"Most of the kids had never seen the Moon through a telescope before. My best memory is one kid looking through the eyepiece and going 'Wooooow' really loudly. That was what I wanted to do!

"Working with the Scout Group has really helped to enthuse my own astronomy. I work full time as well as having children, so sometimes it'll be

"Most of the kids had never seen the Moon through a telescope before. My best memory is one kid looking through the eyepiece and going 'Wooooow' really loudly"



starry outside and my husband will ask if I want to get the telescope out, but I'll be too tired. However, when you've got something like this coming up you want it to go well, so I'll be out there preparing the week before, putting up the telescope and making sure everything's working. It's really been a great experience for me, and I know the kids are always really happy when it's a space night."

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The inspirational Herschels

The dedication of the 18th-century astronomical pair gives **Janet Wilkinson** motivation



On 13 March 1781, astronomer William Herschel went into the back garden of his home in Bath for another night of observation. As he

scanned the sky with a home-built telescope, he made an astonishing discovery – the planet Uranus.

Today, that home is the Herschel Museum of Astronomy (herschelmuseum.org.uk), a celebration of the stars, Herschel and his sister, Caroline – a great astronomer in her own right. It runs events to spread knowledge of the remarkable pair.

“In November 2019 we managed to capture a glimpse of Uranus – in the very garden from where William Herschel discovered it – during a public stargazing evening,” says Janet Wilkinson, a former volunteer who now works at the museum.

To run these evenings, the museum relies heavily on a group of volunteers. It isn’t hard to see what inspires such



The Herschels were both accomplished musicians as well as astronomers

dedication when you look at the Herschels’ story – German immigrants from a relatively poor background who rose up through society, with William eventually named the Astronomer Royal.

“Caroline experienced even more prejudice as she was a woman and disfigured by smallpox,” says Wilkinson. “Yet she would spend the night at the telescope alongside her brother.

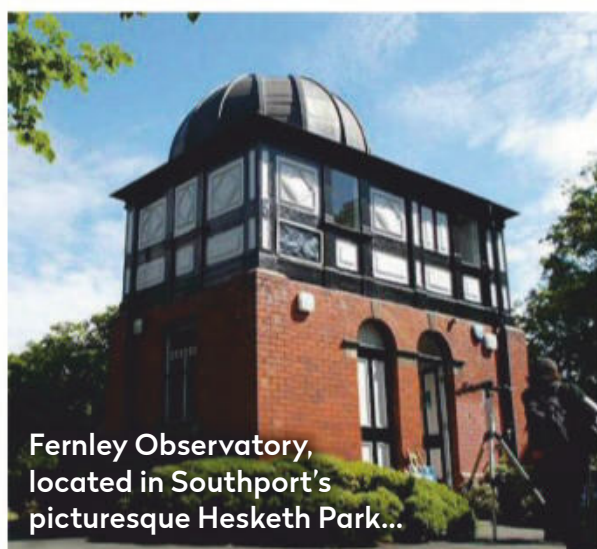


Idyllic: the garden in Bath where William Herschel discovered Uranus

Both were dedicated, crafting their own equipment. “I think their work ethic is what brings people to volunteer,” says Wilkinson. “It’s important to recognise how scientific contributions of the past – particularly women’s – shape our understanding of the world. We mustn’t forget how these leaps in understanding, and how the Herschels’ dexterity, skill and dedication, moved our civilisation forward.”

Antique astronomy

Custodian of Fernley Observatory, **Robert Mount**, finds an elegance in the past



Fernley Observatory, located in Southport's picturesque Hesketh Park...



...has a Victorian refractor that is still operated by its original clockwork mount



In the beautiful Hesketh Park in Southport lies the Fernley Observatory, home of a 150-year-old 6-inch refractor telescope.

The original observatory has a deceptively mundane origin – it was purchased from a catalogue by the wealthy Joseph Baxendell in 1869. Upon Baxendell’s death, it was bequeathed to

the local council on the condition it was made publicly available. Having little idea what to do with it, the council passed its operation to Southport Astronomical Society (southportastro.org). “The council look after the building. We’re responsible for everything inside it,” says Robert Mount, the society member who manages it. “That includes the 6-inch telescope and its clockwork driven mount.”

Maintaining a 150-year-old building hasn’t been easy, and a little help was needed. “In 2002, Sir Patrick Moore came to Southport at the behest of the council to advise on repairing the observatory – it had a canvas dome and the roof had rotted. He wrote five pages on what needed to be done.”

Though the society runs open days to show off the scope’s solar filter, public night-time observations are more of a challenge. “It’s a Grade-II listed building in a Grade-II listed park,” Mount says. “It can be difficult to organise observations and even then only one eyeball can look through the eyepiece at a time.”

Mount hopes to add a CCD camera to the telescope, which would allow many people to see the view at once.

“In my funding bid to the council, I emphasised the importance of maintaining things like this, because the past can tell you a lot about the present and the future: what you mean to do.”

The 10 GREATEST COMETS of recent times

We may be in the middle of a long wait for the next great comet, but as **Neil Norman** discovers, amateur astronomers of times past went through exactly the same thing

Flying visit: Comet Hyakutake made an exceptionally close pass of Earth in late March 1996, reaching a magnitude of 0.0 and generating a huge tail around 100° in length

COMET

	Earth distance at brightest (AU)	Perihelion distance (AU)	Absolute magnitude	Brightest magnitude	Tail length (°)
C/1858 L1 Donati	0.54	0.57	+3.3	+1.0	50
C/1882 R1 Great September Comet	0.98	0.008	+0.8	−17.0	20
C/1910 A1 Daylight Comet	1.12	0.129	+5.0	−5.0	50
C/1956 R1 Arend-Roland	0.66	0.316	+5.4	+1.0	25
C/1965 S1 Ikeya-Seki	1.02	0.008	+6.2	−10.0	60
C/1969 Y1 Bennett	0.80	0.538	+4.5	0.0	25
C/1975 V1 West	0.86	0.197	+5	−3.0	30
C/1996 B2 Hyakutake	0.10	0.230	+7.3	−0.8	>80
C/1995 O1 Hale-Bopp	1.31	0.914	0.0	−0.7	25
C/2006 P1 McNaught	0.81	0.171	+9.5	+5.5	35

This year will see just one comet rise above magnitude +8.0 – C/2017 T2 PanSTARRS – unless another is discovered between now and December, that is. Sadly we are in a very lean period for bright comets, one which prompts the plaintive question, “Why are all the comets today not like those in the good old days?” Those comets that were bright enough to be seen with the naked eye or binoculars, maybe even in daylight.

You could be forgiven for believing this because the countless books and articles on the subject are often paired with images or illustrations of great comets from past ages that blazed across the skies, with huge tails stretching from horizon to horizon, or comets that were visible in broad daylight. But if you take a closer look at the history books going back over 1,000 years or so, you will see that there have been 32 comets which were exceptionally bright – and four of these have been apparitions of Comet Halley. In total, since the year 1800, no fewer than 20 comets have achieved ‘greatness’. This is a very respectable number indeed, but it goes to show that we are in fact no worse off today than amateur astronomers of the past. Our perception of time has compressed the apparitions of the distant past together and stretched those of the recent past further apart.

At any given time there are dozens of comets in the sky of varying brightness, most of which require large telescopes to be seen. So what is it that makes one of these great? First in the set of criteria needed for a historical apparition is the comet’s orbit. A great comet’s passage round our local star must either bring it close to Earth or the Sun respectively. Second, a great comet must have a large nucleus; the larger the nucleus the better in fact, as this will give the potential for a large fraction of the surface to become active. Third is visibility: comets that make close passes to Earth have the potential to be bright, but these will also be fleeting and last just a few days at best. A comet at a greater distance from Earth will linger in the sky for longer and allow ample time for sustained observation. Fourth and finally, to be great a comet should have a dusty composition: dust in

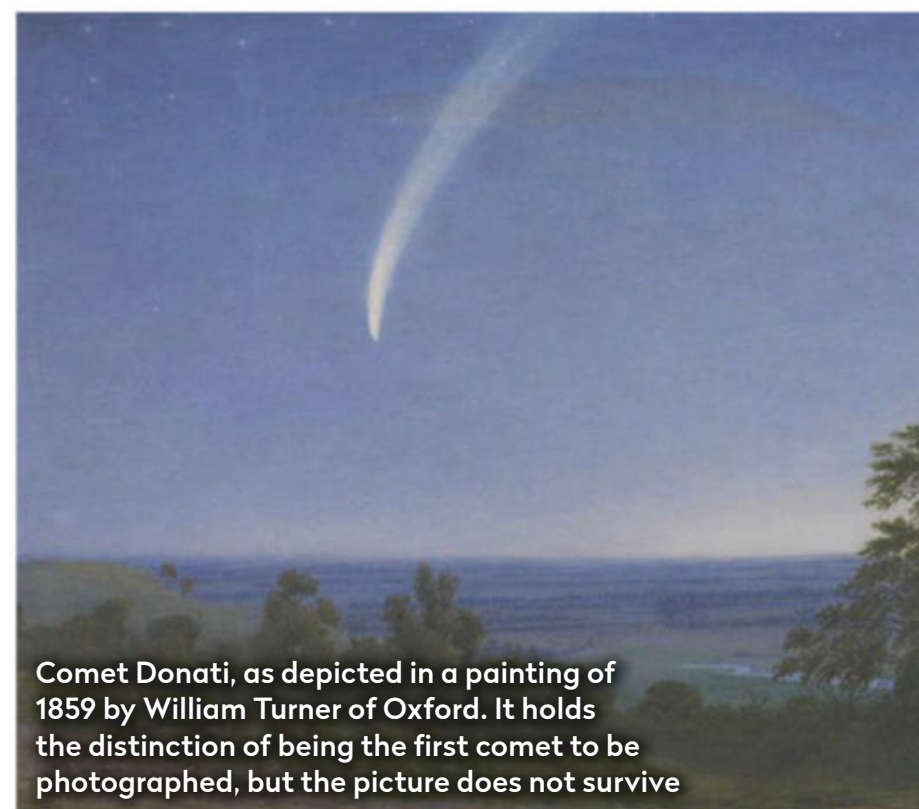
abundance is a requirement for a large, visible tail – an essential trait of great comets.

The table above lists the 10 brightest comets of the last 162 years, together with their distance from Earth when at their brightest, perihelion distance, absolute magnitude (the visual magnitude they would appear if placed at a distance both 1 AU from Earth and the Sun), brightest observed magnitude and finally, maximum tail length.

Now that we have our list of the brightest comets, we can explore the reasons why each one became great, compared to the thousands of other comets that have ventured into the inner Solar System.

Impressive sight

Comet Donati was described by many as the most beautiful comet ever seen. It certainly made an impression upon the art world, with numerous paintings showing it in all its glory. Even Abraham Lincoln is said to have sat at his window gazing upon it. Donati meets our criteria easily: a quick glance tells us that the comet was close to Earth at perihelion and due to that, we had the full benefit of the encounter. It was also a very dusty comet that produced an arcing tail of some 50° in length. ►



Comet Donati, as depicted in a painting of 1859 by William Turner of Oxford. It holds the distinction of being the first comet to be photographed, but the picture does not survive

BUCKWINKEL/ALAMY STOCK PHOTO

► The **Great September Comet** was one of the most prominent members of the Kreutz family of comets (see box, below). At perihelion on 17 September, the comet reached a magnitude of -17.0 as it passed just 480,000km from the surface of the Sun, and was visible in broad daylight. The coma area appeared elongated on 30 September and two fragments were seen. By 17 October, five fragments had been observed. Even with its nucleus undergoing so much disintegration at perihelion, the comet remained visible until 1 June 1883. Subsequent disruption to the nucleus post-perihelion also provided a large quantity of dust to boost the tail. The size of the nucleus must have been fairly large – perhaps a few kilometres – and this, coupled with the extremely close perihelion encounter, ensured this comet's place in the annals of greatness.

The **Daylight Comet** of 1910 brightened very quickly as it approached the Sun. It was discovered by several astronomers from the Southern Hemisphere on 12 January when it was already magnitude -1.0 . The comet reached perihelion on 17 January and was visible in broad daylight with a magnitude of -5.0 . Post-perihelion, it saw a rapid decline in magnitude as it moved into Northern



Hemisphere skies. But a magnificent dust tail made up for the dimming and it had stretched to 50° by the beginning of February. Under normal circumstances this object would not have been a great comet, its absolute magnitude was insufficient and its distance from Earth was none too close. However, its close perihelion pass and dust-rich composition tipped the balance in its favour. However, its long orbital period means it won't be back for around 57,000 years.

Television appearance

On 8 November 1956 **Comet Arend-Roland** was discovered on photographic plates at a magnitude of $+10.0$. Orbital calculations indicated a perihelion pass on 8 April 1957. As the fourth month of 1957 began, the comet's tail dynamics had already started to come to life; a 15° length, streamers and even

▲ Caught on camera: possibly the brightest comet ever seen, reaching mag. -17.0 , the **Great Comet of 1882** was photographed by Scottish astronomer Sir David Gill

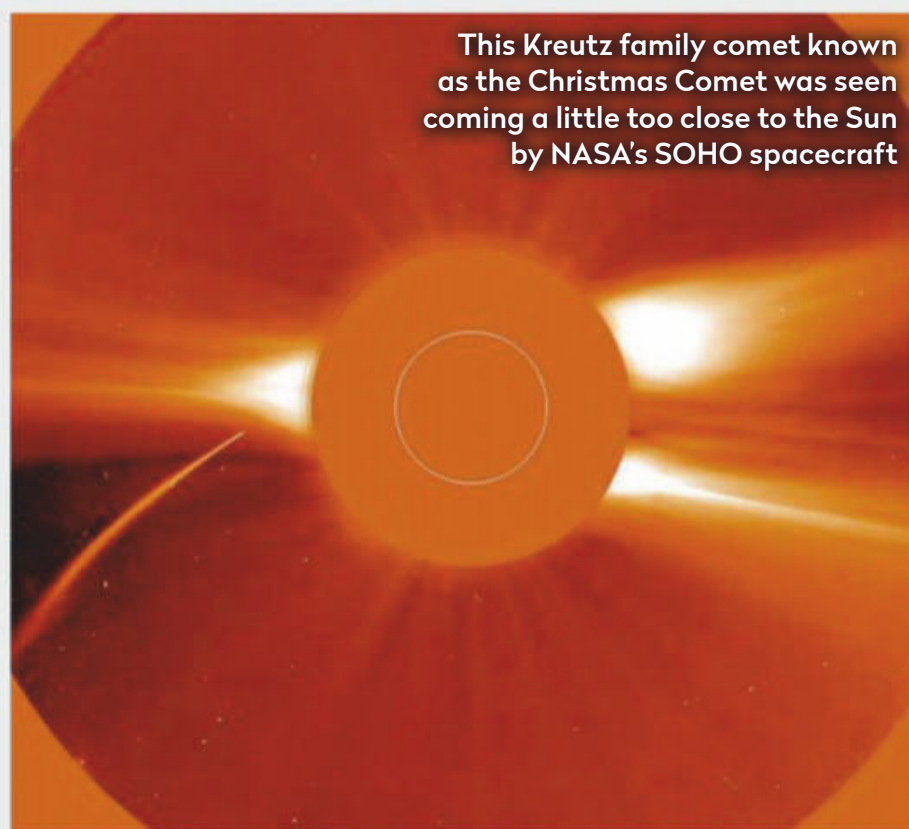
The Kreutz family of comets

This group of sungrazing comets has produced many greats over the years

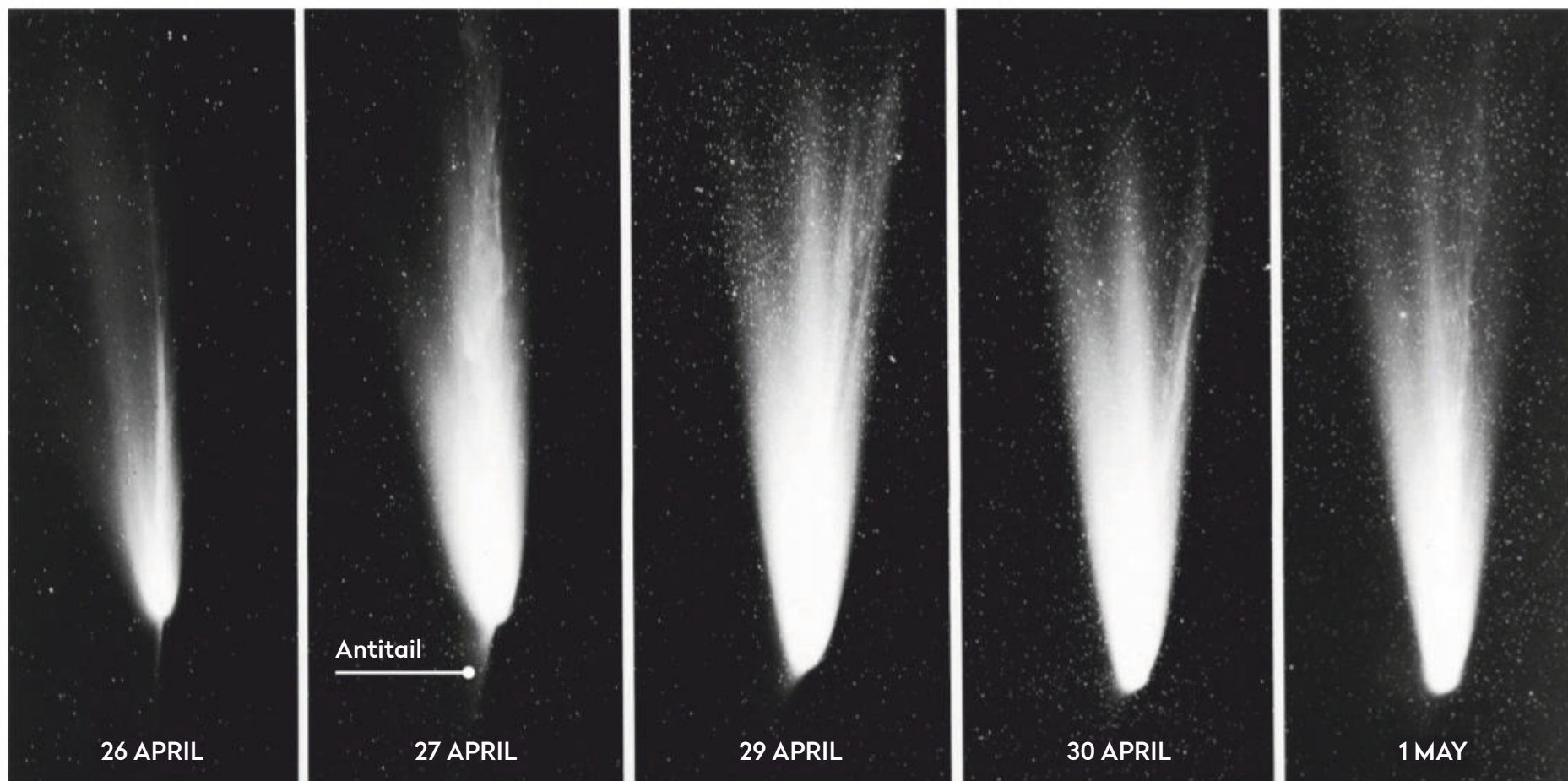
The German astronomer Henrich Kreutz was the first to note in 1888 that several comets that had been seen in the previous 50 years had passed perihelion at extremely close distances to the Sun, and had very similar orbital elements.

Today, these comets are named in his honour and all the members, which are now known to total over 2,000, have perihelion distances that range from 0.005 to 0.009 AU from the Sun's centre. Known to come from the breakup of one large comet in the 12th century, they share other key orbital characteristics too, with aphelion distances around 170 AU from the Sun, orbital periods between 500 and 1,000 years and orbital inclinations of 140° .

The most notable members of the group are the Great March Comet of 1843, The Great September Comet of 1882 and Comet C/1965 S1 Ikeya-Seki. The last spectacular Kreutz comet – and the first one discovered using ground-based telescopes in 40 years – was C/2011 W3 Lovejoy in November 2011, which survived a perihelion pass of just 140,000km from the surface of the Sun and appeared post-perihelion as a 'headless' comet. Its nucleus had disintegrated completely and it then spawned a tremendous tail before fading out completely. Radiation and tidal forces from the Sun account for the demise of many of these comets as they are only tens of metres across.



This Kreutz family comet known as the **Christmas Comet** was seen coming a little too close to the Sun by NASA's SOHO spacecraft



▲ Making history: Comet Arend-Roland, pictured above in April and May 1957, showed an unusually long antitail and became the subject of the first *Sky At Night* programme (right)

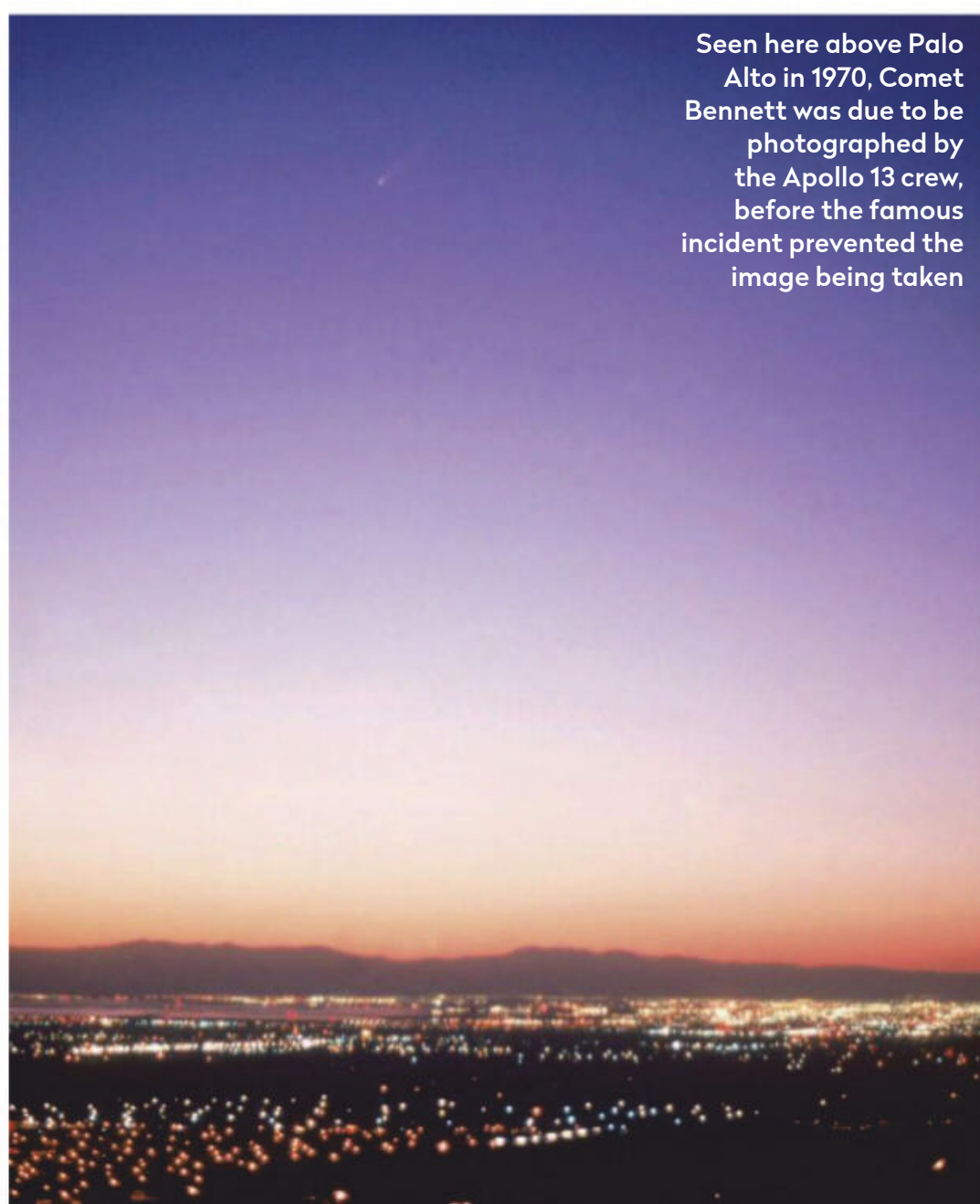


three beams were reported on 29 April. C/1956 R1 is best known for its dart-like appearance due to an anomalous tail, or antitail, first reported on 22 April, measuring 5° in length. By 25 April it was 12° in length, but by the 29th it had disappeared completely. It should also be noted that Arend-Roland became the subject of the very first *Sky At Night* TV programme on 24 April. Compared to the rest of the list, this comet achieved only an average pass of Earth, its saving grace being a close perihelion and a dusty composition. Due to its hyperbolic orbit Arend-Roland will eventually be cast out of the Solar System.

Comet Ikeya-Seki was almost a month from perihelion when it was discovered on 18 September 1965. It became clear that it would approach the Sun very closely at perihelion on 21 October and that it was, in fact, a member of the Kreutz family of comets. On the day of perihelion the comet passed just 450,000km from the Sun and was widely observed in broad daylight across the world at a magnitude of -10.0 . Interestingly, just before perihelion, the comet was seen to fragment into at least three pieces – just as its sister comet had done in 1882. Its nucleus must have been a couple of kilometres in size at best, as its absolute magnitude would suggest. Being a Kreutz family member, it was very dusty in composition and its close pass to the Sun meant it was assured of brightness. The periods of the fragments now range between 876 and 1,060 years.

Decade double

The first of two comets to become great during the 1970s, **Comet Bennett** was discovered on 28 December 1969. In February 1970, the comet reached magnitude $+3.0$ while its dust tail had grown to 12° in length. Its coma displayed short, faint jets at this time. As perihelion approached on 20 March, the comet grew brighter still and reached magnitude 0.0 . It then began to move away from ►



Seen here above Palo Alto in 1970, Comet Bennett was due to be photographed by the Apollo 13 crew, before the famous incident prevented the image being taken



► both Earth and the Sun respectively, but was to be followed telescopically until February 1971. Bennett was another dusty comet with an active nucleus that ensured greatness. Its period is in the order of 1,678 years, meaning it should have appeared in the Dark Ages, in or around the year AD 292. However, searches have shown no sign of this historic return.

Discovered on a photographic plate on 10 August 1975, **Comet West** was to become the great comet of 1976. When it reached perihelion on 26 February, just 6.4° from the Sun, it had a magnitude of -3.0 and between 25–27 February it was visible in broad daylight. This comet also fragmented into two pieces on 7 March and subsequently broke into another two pieces on 18 March. Many observers missed the comet due to it being visible only in pre-dawn skies, and also due to the lack of media attention caused by the failure of Comet Kohoutek to live up to its promise some three years earlier (see boxout, right). However, those who did see it were treated to a long, broad dust tail of immense beauty. Comet West was a very dust-rich comet and another with a small perihelion distance, which ensured greatness. With a huge aphelion distance, calculated to be around 70,000 AU – a whopping 1.1 lightyears – this great comet's orbital period is so vast that we will not see it again for some 558,000 years.

Brief encounter

Comet Hyakutake reached greatness only briefly after it was discovered on 30 January 1996, shining dimly at magnitude $+11.0$, some 2 AU from the Sun. Excitement grew when orbital calculations indicated a close Earth pass of just 0.1 AU in late March 1996 and that it would be visible high in a dark Northern Hemisphere sky. The comet remained at average

brightness until mid-March, when it attained magnitude $+4.0$. As the date of closest approach to Earth came, the comet rapidly brightened and, on 25 March, it became a magnitude 0.0 object with a tail over 80° in length. This was Hyakutake's ion tail; its dust tail didn't form until perihelion came on 1 May 1996. The comet was ascertained to have a nucleus 4.2km in diameter and, other than its close approach to Earth, its characteristics were relatively unremarkable. So much so that, had it passed Earth at 1 AU, it would have barely made binocular visibility.

A true great of modern times, **Comet Hale-Bopp** was located between the orbits of Jupiter and Saturn when it was discovered on 23 July 1995 at magnitude $+10.0$. With perihelion still some 21 months away, its early discovery set a record for amateur comet hunters, which still stands to this day. Subsequently, Hale-Bopp was located on images taken before its

▲ **Record-breaker:** probably the most widely seen comet in history, Comet Hale-Bopp remained a naked-eye object for some 18 months



Long time, no see: Comet West, as seen in 1976 when it reached mag. -3.0 , is notable for its orbital period of over half a million years

Comet Kouhoutek

Promoted as a 'Comet of the Century', Kohoutek fell far short of expectations

For all our focus on outstanding comets, there is one that remains well-known for not living up to expectations – Comet C/1973 E1 Kohoutek.

Discovered on 7 March 1973 by Dr Lubos Kohoutek on a photographic plate, the comet was then at the orbit distance of Jupiter, a record for comet discoveries at the time. Its orbital characteristics were of interest as they showed it would pass close to the Sun, coming within 748 million km. This gave the comet potential to become mag. -10.0, a daylight object.

The media caught on and declared that Kohoutek would become 'The Comet of the Century'. With all eyes on the comet and expectations set so high, when it peaked at a very respectable mag. -3.0 it was inevitably and unfairly declared a huge let down. The reason for the failure may very well have been due to the comet undergoing an outburst at discovery, giving a false magnitude for astronomers to work with.

Nevertheless, it remains an instructive lesson in how not to promote astronomical events.



Don't believe the hype: Comet Kouhoutek, as photographed on 11 January 1974 from Arizona, failed to live up to expectations

► **Naked-eye view:** the brightest comet in 40 years, Comet McNaught peaked at mag. -5.5 in January 2007



Neil Norman is the creator of the Comet Watch Facebook group and contributes to the comets section in the *Yearbook of Astronomy*. A fellow of the Royal Astronomical Society, asteroid 314650 is named in his honour



discovery dating back to 1993, which showed that the comet was active at a distance of 13 AU from the Sun, where most comets are still dormant. It became a naked-eye object in May 1996 and remained so until December 1997, an impressive 569 days, or around 18 months – yet another record held by this comet. Comet Hale-Bopp was a monster of a comet with a nucleus estimated to be between 60-80km in diameter; had it passed Earth at a distance akin to

Comet Hyakutake, there it no doubt it would have been hailed as the 'Comet of the Millennium'.

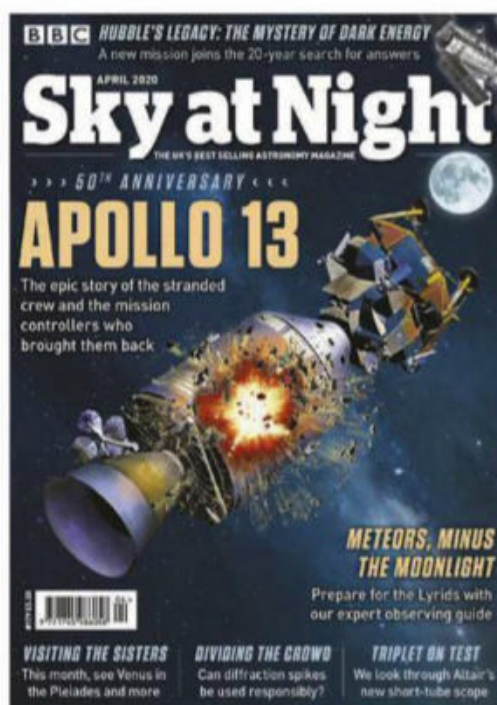
Daylight visitor

The most recent comet on our lists of greats, **Comet McNaught**, was discovered in CCD images on 7 August 2006, when shining at a rather dim magnitude of +17.0. Its brightness had only risen to mag. +9.0 by the time it went into solar conjunction in December, but when it was picked up again in January 2007 it had reached a naked-eye magnitude of +2.5 and became visible low in the Northern Hemisphere sky at dusk. Perihelion arrived on 12 January at a distance of just 0.17 AU from the Sun, which saw the magnitude of the comet rise to -5.5, making it visible in the daylight sky around 7° southeast of the Sun. Closest approach to Earth came on 15 January, at a fairly large distance of 0.82 AU. After perihelion McNaught sprouted a magnificent curved dust tail that displayed synchronous bands and striations all the way through its 35° length. This was again a case of a comet becoming great due to its close perihelion approach and very dusty composition. The orbit of this comet was initially estimated to be 6.5 million years, which has now been reduced to 93,000 years.

We have been treated to some very special comets over the past 160 years or so, but in terms of pure greatness there can only be one true winner – and that is Comet C/1995 O1 Hale-Bopp. It is just a shame it will not be back for 2,500 years or so. As we await its return, there are sure to be many others discovered by amateur astronomers watching the skies. Who knows, perhaps the next one will bear your name. 🌌

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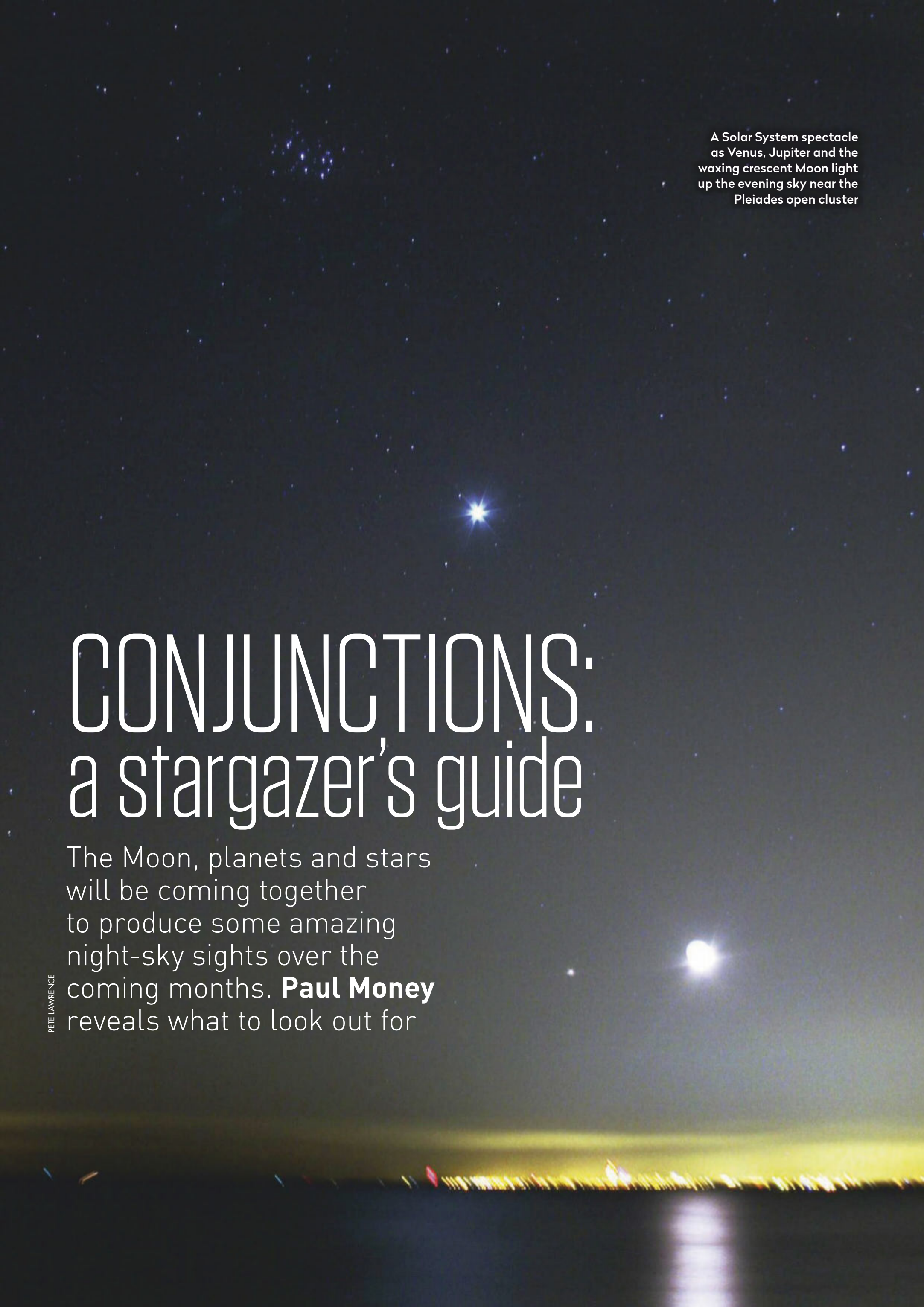
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A Solar System spectacle
as Venus, Jupiter and the
waxing crescent Moon light
up the evening sky near the
Pleiades open cluster

CONJUNCTIONS: a stargazer's guide

The Moon, planets and stars
will be coming together
to produce some amazing
night-sky sights over the
coming months. **Paul Money**
reveals what to look out for

PETE LAWRENCE



Conjunction: what a funny-sounding word it is, yet in the field of astronomy this phenomenon can give us some wondrous night-sky sights, ranging from naked-eye views, through to binoculars and even telescopic viewing.

Generally speaking a 'conjunction' is the name given to two or more celestial objects close together in the night sky. The most commonly observed conjunctions involve the Moon, often as a crescent in the evening or morning sky, along with any of the bright planets – Venus, Mercury, Mars, Jupiter or Saturn. You can also see conjunctions between the Moon and bright stars or even between the planets themselves, so there is quite a range of possible combinations. Some involve more than two objects, such as when two planets are in conjunction and are joined by the Moon. There are also times when incredibly close conjunctions set two objects in the same telescope field of view, or in really special cases, show Venus or Mercury transit across the face of the Sun.

You may already have come across the term in astronomy guides, yet if we went by its strictest definition then some events called conjunctions would probably not qualify. To be precise: a conjunction is a line-up of at least two celestial objects in the sky relatively close together that share the same Right Ascension (RA) or ecliptic longitude in the sky. RA is the equivalent of longitude on Earth but projected onto the celestial sphere. The ecliptic is the plane of Earth's orbit and appears to us as the apparent path of the Sun across the sky. Ecliptic longitude is measured along the ecliptic eastwards from the spring equinox.

Even within astronomy there are different meanings of the word conjunction. When a planet, either outer or inner, lies on the other side of the Sun to Earth it is said to be at 'superior conjunction'. When an inner planet lies between Earth and the Sun it is at 'inferior conjunction'.

Often a conjunction will occur during daytime or when the objects are below the horizon, and this is where the definition becomes more relaxed. If the objects are very bright, such as a crescent Moon and Venus, then daylight viewing can be possible, but if the objects have set below the horizon they won't be visible. So conjunction can be applied in quite a loose context, to refer to objects that are viewable above the horizon in twilight or at night, even if they are not, at that point, at the exact moment of conjunction. If the objects are at their closest, then this is known as an 'appulse': the minimum separation between the two bodies that occurs just before or after the true conjunction.

Conjunctions really capture our attention, which makes them ideal targets for public stargazing events, or for inspiring young astronomers and newcomers to look up at the night sky. They are also easy to capture with a smartphone camera, giving more people the chance to preserve the moment and share with friends or on social media.

Over the following pages we'll look at some fascinating conjunctions coming up over the next few months between planets, the Moon and stars. Keep a look out for these beguiling events, and make sure you follow our monthly *Sky Guide* (see page 43) in every issue for more information about how you can observe them.

▲ **Close range:** (above left) Venus and Jupiter as they appeared together in the evening sky in December 2008; (above top) the large circular silhouette of Venus shows up starkly against the Sun's disc during a transit in June 2012; (above) the conjunction of Jupiter and the Moon in November 2012

Mercury and Venus

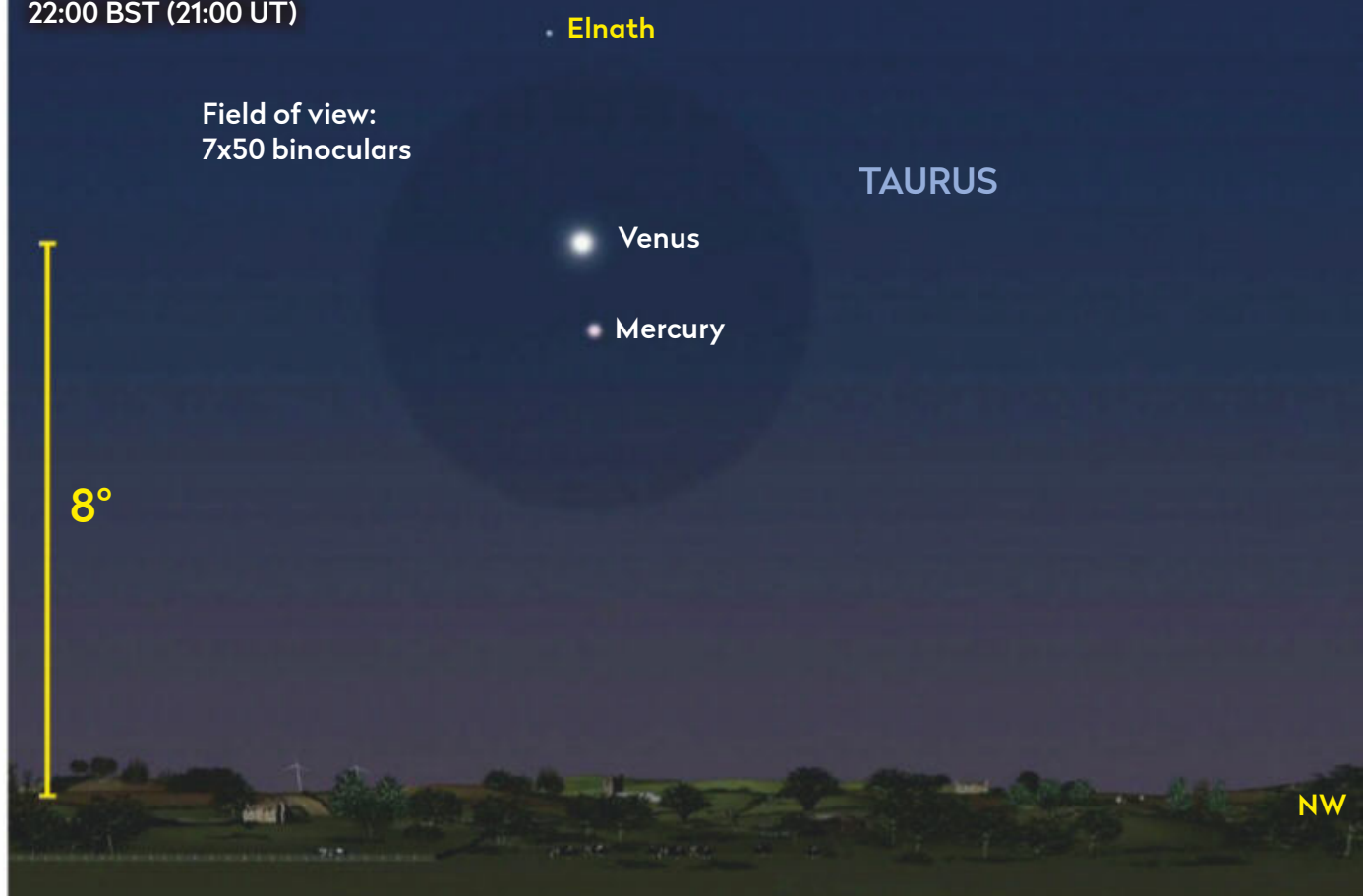
When: 21 & 22 May

See it with: Naked eye and binoculars

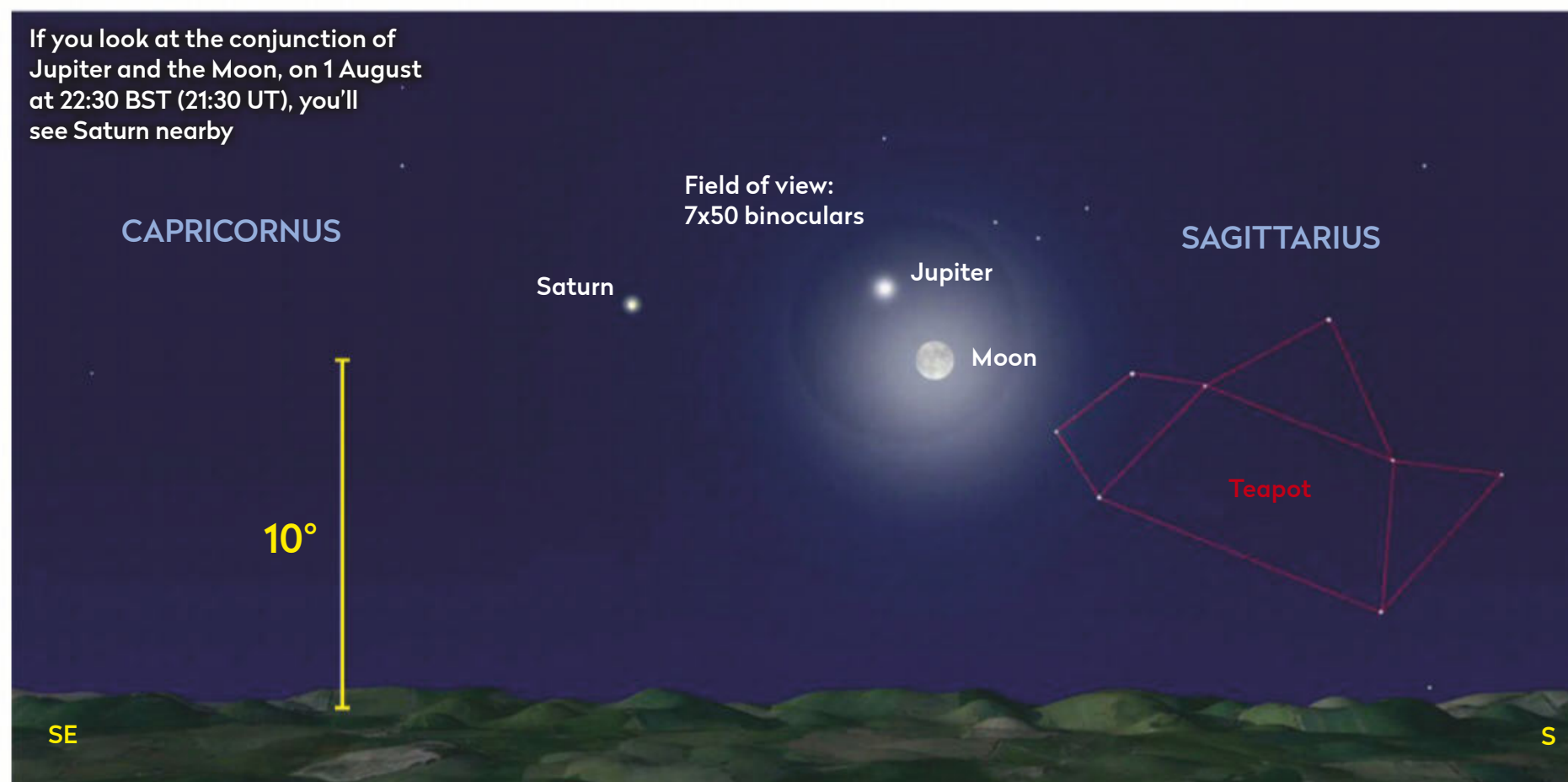
How to see it: During evening twilight look towards the northwest horizon about 45 minutes after sunset

Mercury and Venus come together for a stunning conjunction in the early evening of 21 and 22 May. On the 21st the fainter Mercury lies below the dazzling Venus, and the following evening Mercury lies to the left of the brilliant planet so you won't be able to mix them up. They both fit nicely in the view of 7x50 and 10x50 binoculars and will be very close as seen with the naked eye. Two days later on the 24th, they are joined by the slim crescent Moon, with Mercury forming the apex of a shallow triangle with the Moon and Venus. They set quickly so catch them early in the evening.

To see Mercury and Venus, look towards the northwest on 21 May around 22:00 BST (21:00 UT)



If you look at the conjunction of Jupiter and the Moon, on 1 August at 22:30 BST (21:30 UT), you'll see Saturn nearby



Moon and Jupiter

When: 1 & 28 August

See it with: Naked-eye and binoculars

How to see it: Spot it above the southeast horizon during evening twilight

Look towards the southeast horizon at around 22:30 BST (21:30 UT) in evening twilight. This time it's the Moon and Jupiter in conjunction and the Moon is at gibbous phase, just two days before it's full. There is also a bonus as Saturn lies to their left on 1 August. You will be able to view this conjunction with the naked eye if your horizon is not cluttered, and 10x50 binoculars will show Jupiter and the Moon in the same field of view if you do have a clear view. The Moon encounters Jupiter again on the 28th for an encore if you miss the first event. ►

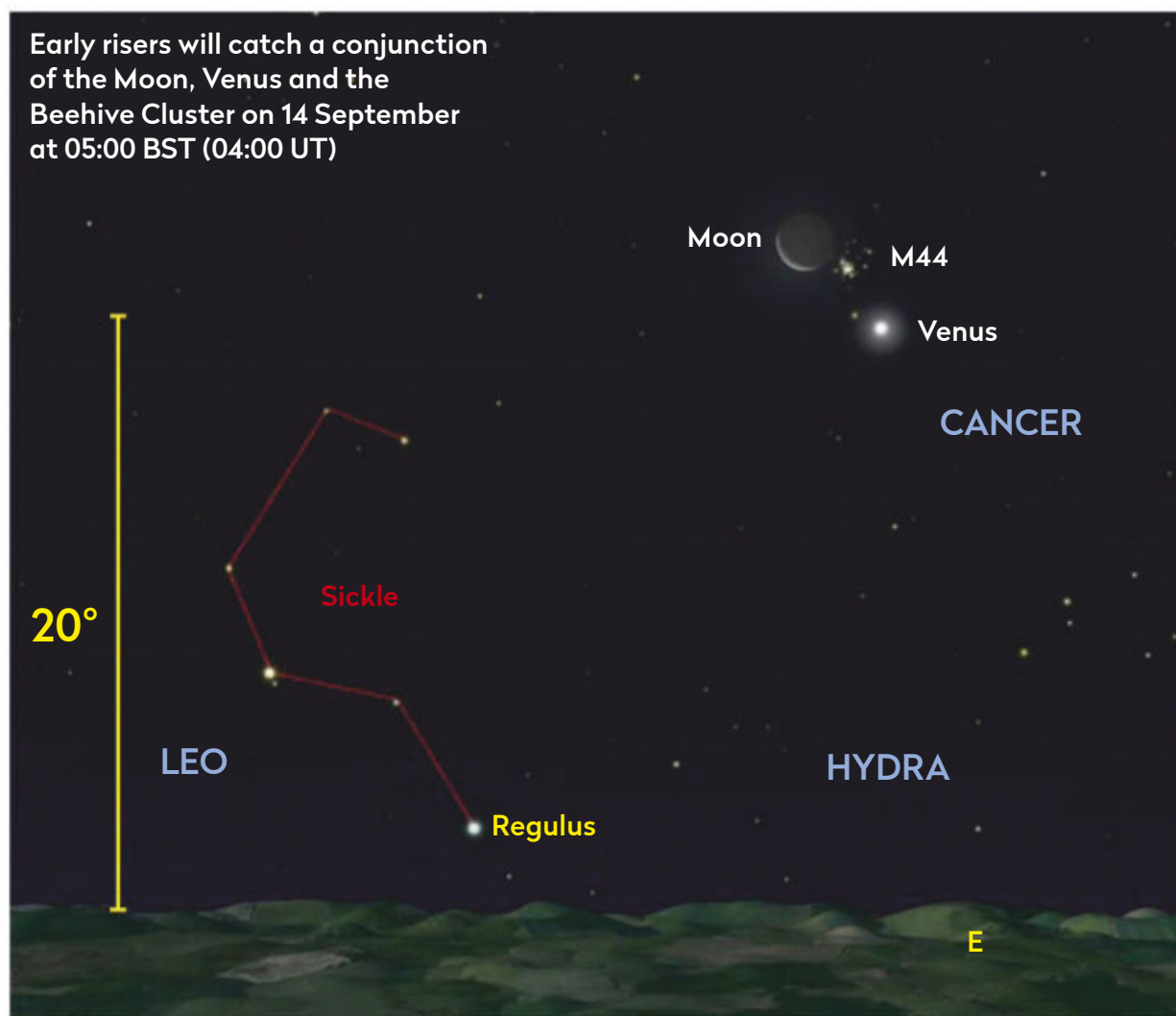
Moon, M44 and Venus

When: 14 September

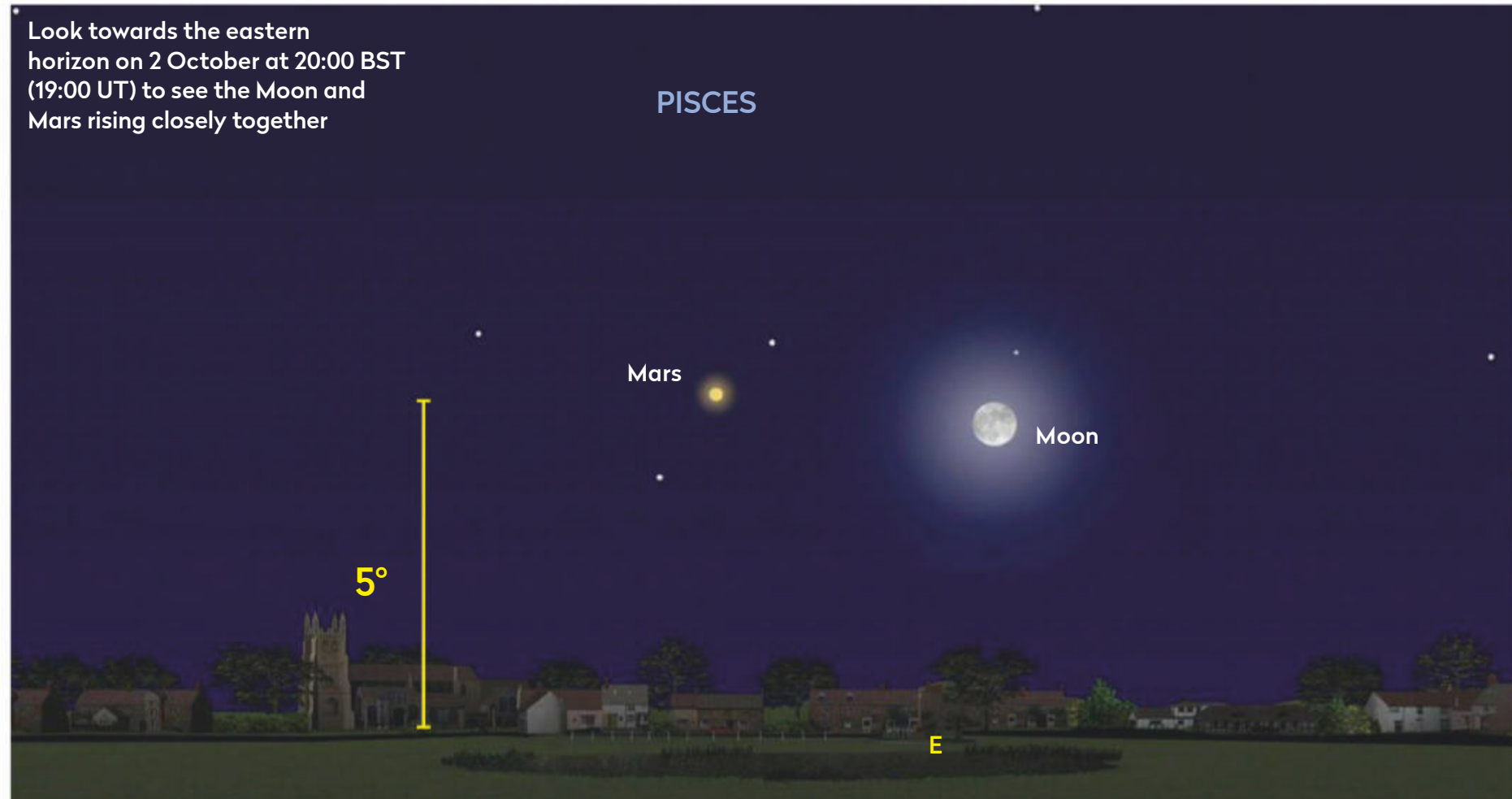
See it with: Naked eye and binoculars

How to see it: Look eastward in the very early morning, around 4am

Normally the most observed conjunctions are seen in the evening sky, but you'll need to set your alarm clock for this one as it's best seen around 4am towards the eastern horizon. The slim crescent Moon and dazzling Venus lie either side of the wonderful star cluster M44, the Beehive Cluster. The Moon and Venus will be viewable with the naked eye and you may be able to glimpse the cluster, but the view through binoculars will be special indeed, enhancing the appearance of the Beehive. This is one of the occasional conjunctions that involve a deep-sky object, so it's definitely worth making the effort provided you have clear skies.



Look towards the eastern horizon on 2 October at 20:00 BST (19:00 UT) to see the Moon and Mars rising closely together



Mars and the Moon

When: 2, 3 & 29 October

See it with: Naked eye and binoculars

How to see it: Look eastward around 8pm

The Red Planet is just 11 days away from opposition and at its best for Northern Hemisphere viewers for this conjunction. On 2 October, the Moon – just one day past being full – lies to Mars's lower right. Look towards the eastern horizon from about 8pm onwards as both rise higher and the Moon creeps closer to Mars. The pair will be closest just as they set the next morning. You will find that 7x50 and 10x50 binoculars give good views throughout the night, and for a bonus look out for the Moon and Mars lying close together yet again on the 29th in the early southeastern evening sky.



Paul Money is an experienced astronomer and author of the annual astronomy guide *Nightszenes*

◀ View the 'great conjunction' of Jupiter and Saturn on 21 December at 17:00 UT...

▼ ...and use a telescope to pick out each of the planet's moons before they get too low in the sky (south-up view)

Jupiter and Saturn

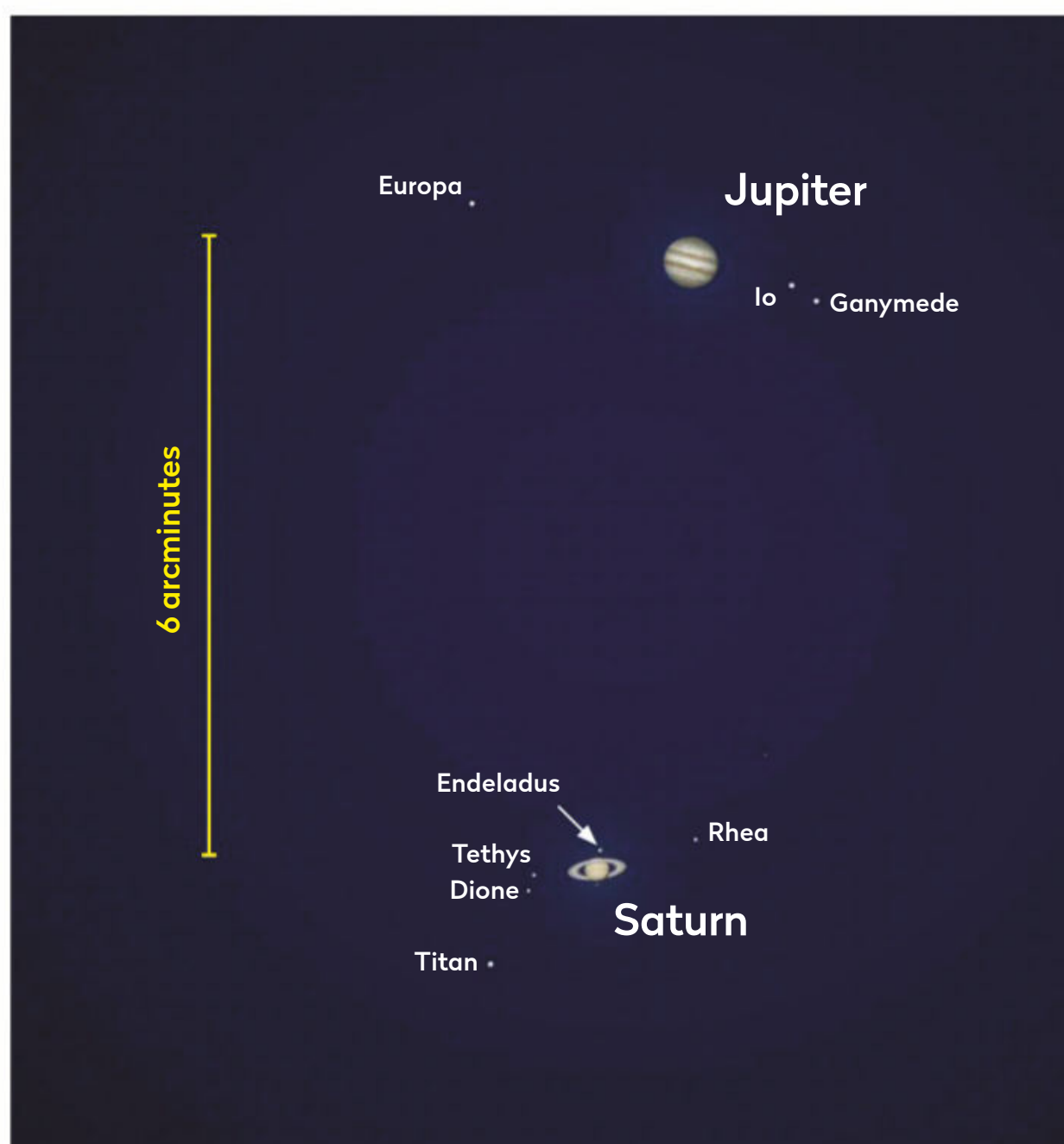
When: 21 December

See it with: Naked eye, binoculars and telescope

How to see it: Early evening bright twilight towards the southwest horizon

Christmas is an interesting time of year for a conjunction of bright planets to occur in the evening twilight, often giving rise to 'Christmas Star' reports. These are usually prevalent when Venus is visible at Christmas, but Jupiter is the next brightest planet and it's the one that will be catching our attention. On 21 December, after months slowly approaching each other, Jupiter and Saturn meet up for a spectacular 'great conjunction'. They will appear so close in the sky that for a naked-eye view they may look like a single, bright object. They will be low in the evening twilight and will set quickly, so a good uncluttered southwestern horizon is essential in order to view this conjunction.

Binoculars will separate them into two objects with Saturn, the fainter of the two, lying above the mighty Jupiter. However, if you can use a telescope then aim it at them before they get too low. You will not only see them as discs, but may even see Saturn's rings and Jupiter's belts in the same view, along with the four Galilean moons of Jupiter and Saturn's largest moon, Titan. This will be a brilliant conjunction as the year draws to a close. 🌌





Practical astronomy projects for every level of expertise

DIY ASTRONOMY

Safely align an equatorial mount using the Sun

How to use the brightest object in the daytime sky to achieve polar alignment

There's a lot of talk about the accuracy of polar alignment being essential for achieving great astronomy. It's true that the more accurately an equatorial mount is aligned with Earth's polar axis, the more faithfully the telescope will track the sky. However, the accuracy with which your mount needs to be polar-aligned will depend on what you are using your scope for. If you are just going to go out observing or imaging the Sun, Moon or planets, accurate polar alignment really is overkill. These targets will tolerate some drift. If you are autoguiding, or imaging faint deep-sky objects or comets, it may be a different story. More on this later.

Not everyone has an observatory or is in the situation where the mount can be permanently set up and kept polar-aligned. Perhaps you are unable to view Polaris from your location or find yourself in a situation where you need to get your telescope set up during the day. This could be, for example, to do solar imaging or observe a bright planet such as Venus, which is accessible in the daytime sky. In these circumstances, there is a method you can use to get your mount reasonably polar-aligned during daylight hours – without being able to see any stars, let alone Polaris.



Indeed, there is a bright object we can use to achieve polar alignment that is easily visible on a clear day – the Sun. This method (see our Step by Step guide, right) must be used with great care. Remember to always use certified solar filters – such as Baader film over the front of the telescope or objective, or a Herschel Wedge for a refractor. You will need to take these precautions due to the Sun's excessive heat and light. These reduce the danger of setting fire to your clothing, or worse still, permanently damaging your eyesight or equipment.

Daylight viewing

The method outlined in our Step by Step guide will enable you to get sufficiently accurately polar aligned during the daytime.

It's been found to be accurate enough to help to get set for solar imaging, and to find planets and even bright stars using computer control. It's true to say that when you are imaging Solar System objects, the methods used can be quite tolerant of a bit of image drift if your mount is not accurately polar aligned. However, when it comes to deep-sky imaging the targets are less tolerant, but our method benefits from allowing you to autoguide to an extent.

After carefully performing a daytime solar polar alignment, and if the skies stay clear, you will find this alignment can be sufficient for autoguiding without having to re-adjust the mount's polar alignment so that it is re-centred accurately on Polaris. That's the beauty of autoguiding: if the stars do drift slowly across the field of view, automatic adjustments by the autoguider compensate for this drift.

We don't get many clear nights, so don't waste those precious hours tinkering about trying to get your mount's polar alignment absolutely spot on. In many cases you really don't need it. Instead, try our method of polar aligning – with our simple guide – using the brightest object in the daytime sky.



Dave Eagle is an astronomer, astrophotographer, planetarium operator and writer

What you'll need

- ▶ A clear sunny day – remember to never look at the Sun directly
- ▶ An equatorial mount and telescope
- ▶ A handset or computer control
- ▶ A compass or mobile phone
- ▶ A sheet of white paper
- ▶ A certified solar filter

Step by step



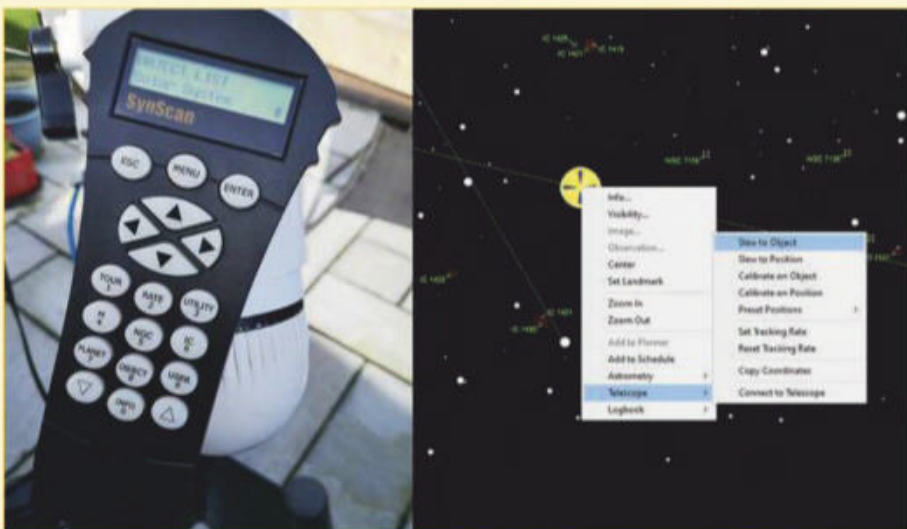
Step 1

Find the direction of north at your location. If it is your home location, you may already know the rough direction to point the mount. If you do not know where Polaris will be in the sky, use a compass or mobile phone to find where magnetic north is.



Step 2

Set up the equatorial mount with the north leg and counterweight pointing in the approximate direction of north. It will be a rough alignment at this point, but the closer it's pointed towards true north, the less work there will be in Step 4.



Step 3

Use a computer, or the handset if the software allows, to select and slew the scope to point at the Sun. For safety, ensure any finder has a secure cap fitted and the scope is not left unattended. Always use certified solar filters on the front of the scope or objective.



Step 4

It's likely the scope is not pointing directly at the Sun. Without moving the mount's Right Ascension and declination controls, you can move the position of the head using azimuth and latitude bolts. Get the Sun as close to the centre of the field of view as possible.



Step 5

Look at the shadow of the telescope cast onto the ground or safely let correctly filtered light in through the telescope to refine the centre of the Sun's image. The mount should now, to all intents and purposes, be polar aligned.



Step 6

Lock down the mount so it doesn't move and start observing. Monitor the movement of your target. If it drifts north or south in the field of view, the polar alignment is slightly out. If required, revisit Steps 4 and 5 until any image drift stops. 🌞

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

C/2017 T2 PanSTARRS passes M81 and M82

Comets are tricky targets, but follow our simple steps to capture this galactic encounter

This month sees the climax of the passage of comet C/2017 T2 PanSTARRS, as it reaches its brightest predicted magnitude while passing close to the galaxy pair known as M81 and M82. We first reported on this comet in the middle of 2019, when there was conjecture that it could become bright enough to be seen with the naked eye.

Sadly, this turned out to be wishful thinking, but on the plus side the comet has been a steady, albeit dimmer, performer during its time in our skies. It's also well-placed for UK viewing.

As it passes M81 and M82 the comet is expected to be shining with an integrated magnitude of +11.6. With a small apparent size, the comet should be on a par with the galaxies, making for an interesting and balanced photograph as long as the clouds stay out of the way.

On the right track

Comets are notoriously awkward objects to image against starry backgrounds. While we go to great lengths to remove the effects of Earth's rotation using equatorial tracking or autoguiding mounts, comets mess this up completely by having their own relative motion against the stars. Tracking the stars keeps them crisp and sharp, as long as your polar alignment is accurate, but a comet will often blur.

Just to complicate matters, a comet's rate of motion varies depending on how close they are to Earth and the inclination of their orbit to the line of sight of the observer. In the case of C/2017 T2 PanSTARRS, when close to M81 and M82 its motion across the sky is in the order of 50 arcminutes a day.

Converting this to a minute rate, 50 arcminutes a day 24 hours is equivalent to 2 arcseconds every



▲ **Bright sights:** a simulated image of C/2017 T2 PanSTARRS (bottom left) approaching galaxies M81 and M82 (top)

minute, which is not too bad. With a required field size of at least 2° to capture the comet and galaxies comfortably at closest approach, this rate of movement is equivalent to 1/3,600th of a 2° field every minute. Wider fields will be more tolerant of the comet's motion.

Exposures in the order of 30, 60, 90 and 120 seconds should work fine for single shots. If you intend to stack images, the situation is a bit different as stacking accumulates timed motion. Stack sixty 60-second exposures for example and you're

integrating a scene which covers an hour's worth of cometary movement. Using the rate above this equates to 120 arcseconds or 2 arcminutes, roughly 1/15th the Moon's apparent diameter. As comets go, this isn't excessive. It's helped by the fact that T2 PanSTARRS is now moving away from Earth, it's closest approach having occurred in late December 2019.

Various techniques exist for processing comets with deep-sky backgrounds. One popular method is to process for the background stars and galaxies, getting your processing software to remove any moving objects between frames – ie, the comet. Then process for the comet itself, attempting to remove background stars. Finally, both sharp images can be combined to give a view showing the comet in sharp relief against its backdrop. But the slower motion of T2 PanSTARRS can work against you as there's not enough motion to reveal it as a convincing moving entity between frames.



Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

Recommended equipment: Camera with a lens of focal length 600mm (APS-C) or 1,000mm (full frame)

✉ **Send your images to:**
gallery@skyatnightmagazine.com

Step by step



STEP 1

Your image scale will be determined by the lens or scope attached to your camera's front. A lens of 600mm focal length attached to a non-full frame DSLR (eg, APS-C) will deliver a $2''$ (long frame dimension) field. A full frame camera with a 1,000mm lens achieves the same field: $2''$ is the smallest workable size for close approach.



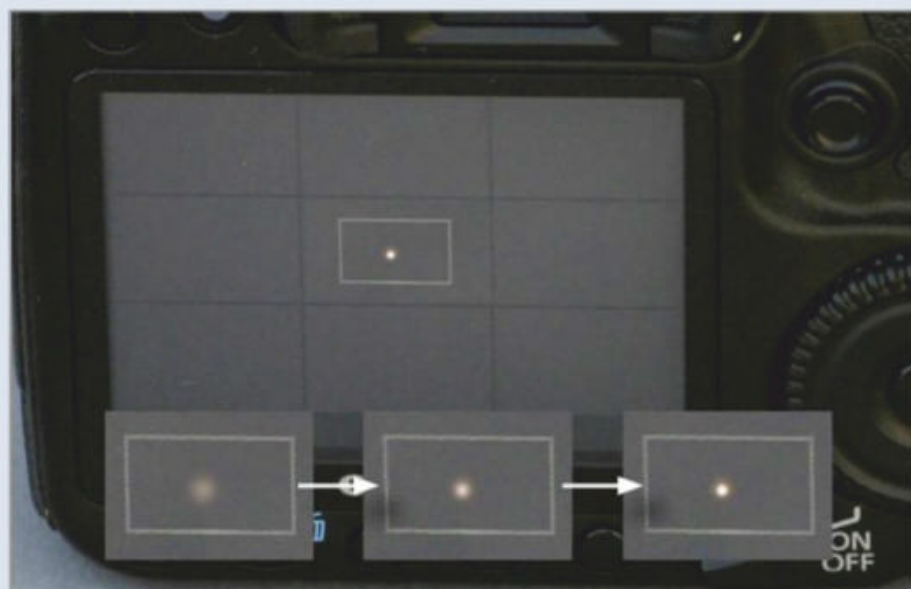
STEP 2

An aligned tracking mount is needed. The M81/M82 field is located near the northern celestial pole. The apparent movement of stars due to Earth's rotation is reduced compared to what you'd see if the field were closer to the celestial equator. Maximum exposures depend on the setup, but a minimum of 30-60 seconds is achievable.



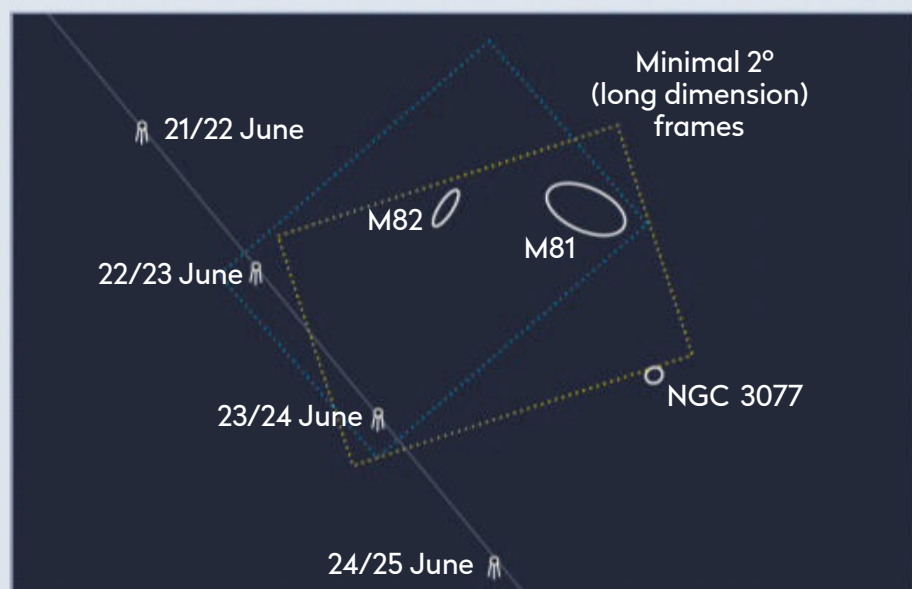
STEP 3

Set your camera's ISO to a mid-low value, say ISO 800-1600. For lens-based setups, fully open the lens (lowest f-number). For 30" exposures, use the camera's 30" setting. For longer values, set the camera to bulb mode and use a remote shutter release to control shutter opening. Use a stopwatch to control exposure lengths.



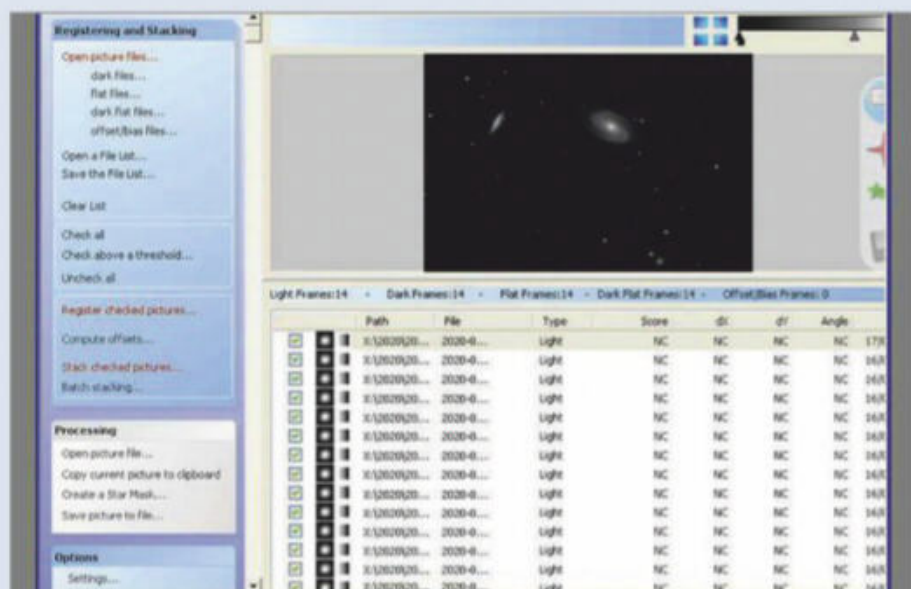
STEP 4

Accurate focusing is important, so take your time. Pre-focus on a star such as Dubhe (Alpha (α) Ursae Majoris) using your camera's Live View facility. Set the Live View display to maximum magnification. Approach focus, achieve it and wind through it. Repeat until you recognise what focus looks like, then wind to it.



STEP 5

The night of 23/24 May presents the closest pass with the comet passing M81 by $1.5''$. Align the camera frame so the mid-point of the line joining the comet to M81 is in the centre; having both objects on the frame diagonal works well. It may also be worth noting that there are several other faint galaxies in the vicinity (see page 56).



STEP 6

The comet's slow speed may allow several minutes of images to be stacked without blurring. DeepSkyStacker can stack and average images, allowing flats and darks to be used. Darks are equivalent exposures with the lens cap fitted. Flats are an image of an evenly illuminated white light source, exposing to 50-70% saturation.

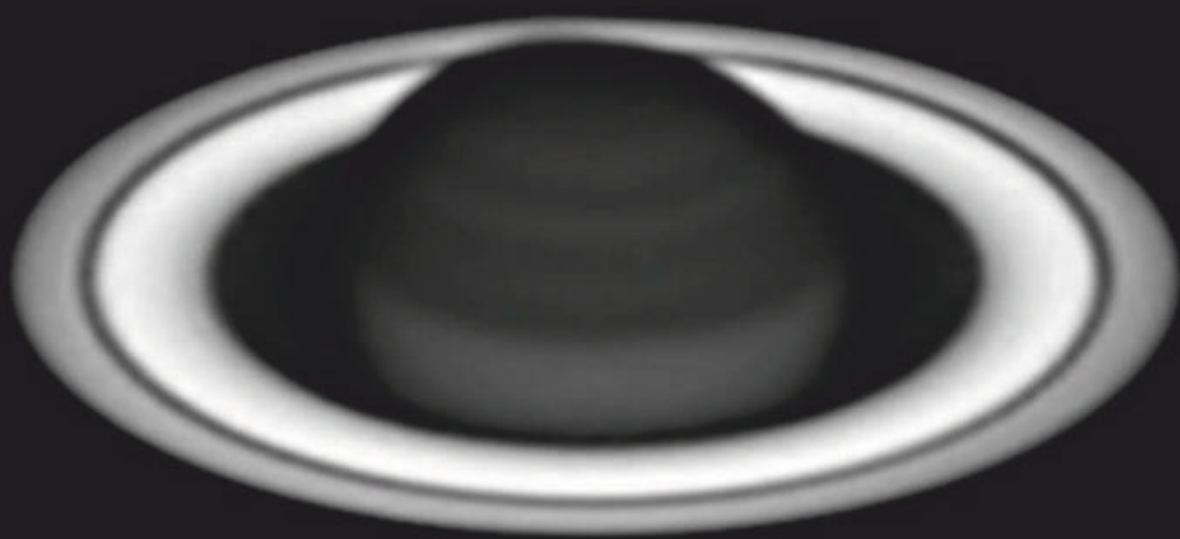
Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

IIAPY Masterclass A shot in the dark

How to transform a familiar view of a gas giant by using a methane filter

The final image of
Black Saturn, ready
to submit to the IIAPY



Methane filters used to be costly, but in recent years lower-cost Chinese filters have come onto the market, allowing for the imaging of Jupiter and Saturn in this wavelength. As a result, images of Jupiter taken in the methane band are now much more commonplace. Even so, detailed images of these planets in this band are difficult to take, mainly due to the lack of light. There are a couple of reasons for this. Firstly, the methane band in the near-IR is narrow and to get good contrast the methane filter also needs to be in the same narrow band pass. Secondly, the spectral response of planetary cameras falls off in the infrared band; with CMOS cameras having peak responses of only 25-40% at 890nm, the methane filter band pass.

To compensate for the lack of light, methane images tend to require much longer exposures, making them more

prone to smearing by atmospheric movement. The low light also means that images tend to suffer badly from noise or unwanted artefacts. On top of this the longer wavelength reduces the resolution of the scope significantly, as the size of the diffraction disc is directly proportional to the wavelength. It's an interesting challenge getting decent surface details on Jupiter using methane-imaging techniques, while detail on Saturn is even more so as it has a much lower surface brightness due to its greater distance from the Sun. It requires even longer exposures and there's a likelihood of more noise. Good Saturn images, taken in the methane band and showing disc details, are rare.

Back in black

My image of Saturn was taken on a night of good seeing in early August 2018. Even though the planet was visible at only 15° altitude from my suburban location, the image was relatively steady in my 444mm Dobsonian telescope, so I thought I'd have a go at imaging in methane and see if I could capture

At the 2019 IIAPY awards I was fortunate enough to take third place in the Planets, Comets and Asteroids section for my image 'Black Saturn'. This image was taken through a methane filter, a device that makes this favourite object look quite eerie with the familiar view being replaced by one showing a planet with sooty belts on a dark disc surrounded by a set of much brighter rings.

Methane (CH₄) is a major component of the gaseous atmospheres of both Jupiter and Saturn. It makes its presence known by absorbing light in several narrow spectral bands, including one in the near-infrared (near-IR) centred on a wavelength of 890 nanometres. Imaging through a filter with a narrow band pass (allowing it to capture a small defined bandwidth and exclude others) centred on this wavelength allows you to see where the methane is by which areas look dark. Such images are scientifically useful as they can show features and activity not visible in normal optical images.

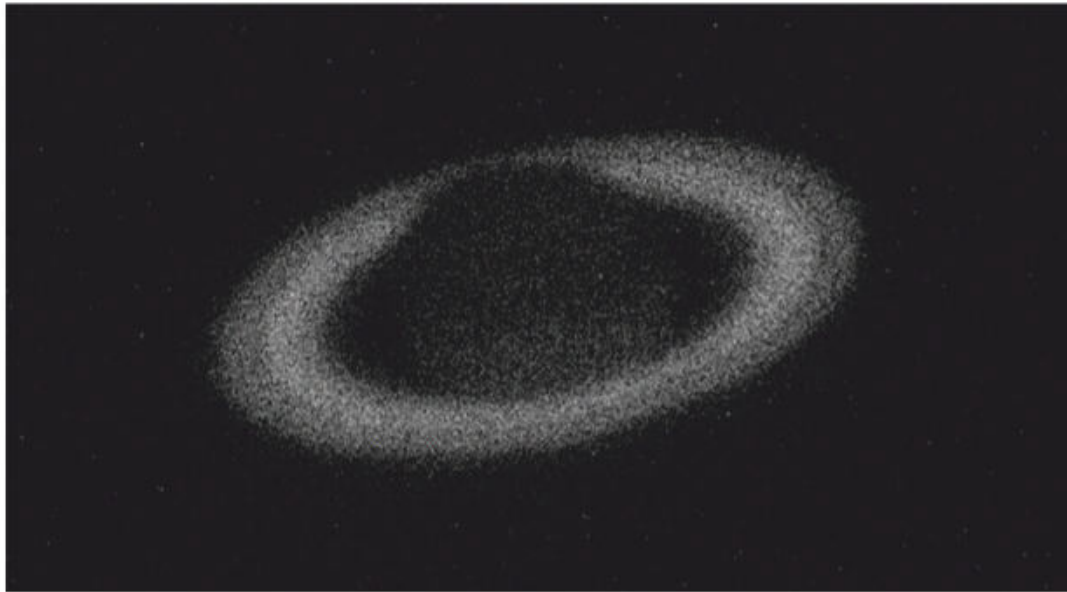
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3 QUICK TIPS

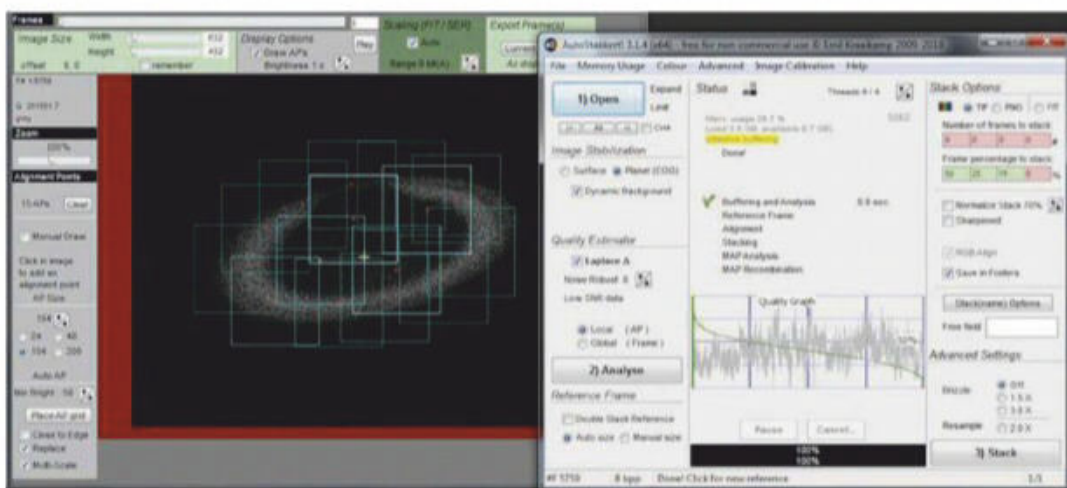
1. Pick a night of superior seeing to attempt methane imaging of Saturn as you will need long exposures at high gain and you don't want too much atmospheric smearing.
2. Measure your filter thicknesses and swap your methane filter with one of the same thickness, which allows more light through, as this will allow for much easier focusing.
3. Record for many minutes to build up a long-accumulated exposure time, so that – when you stack – the amount of noise (unwanted artefacts) in the final image is not too bad.



▲ Stage 1: one of the best raw frames from the video showing the high levels of noise – unwanted artefacts – that are present



▲ Stage 2: using a 610nm filter, with a much greater light transmission than the methane filter, for focusing



▲ Stage 3: the stacking process in AutoStakkert!



▲ Stage 4: processing the stacked image in RegiStax

belt detail and surface features on the disc. Using a low-noise ZWO camera with a mono chip sensitive in the infrared (a Sony IMX290 sensor) and operating at f/12, I had to use a gain of just over 500x and a 32-millisecond exposure to get a bright image on the preview screen which – however – meant it was very noisy (Stage 1).

Swapping to a 610nm filter with a much greater light transmission than the methane filter, but with the same thickness, allowed me to get the focus on a much less noisy image – with less unwanted artefacts (as shown in Stage 2). Swapping back, I then captured one methane video of 5,700 frames and another of 8,000 frames, giving a total exposure time of 7.3 minutes – a long-enough accumulated exposure time to help reduce noise to tolerable levels.

Processing involved picking the best 50 per cent of frames and stacking in AutoStakkert!3, where I selected a very high 'Noise Robust' value of 8 to stabilise the frames. I manually placed alignment boxes over the disc and rings of size 104 (Stage 3).

Stacking was then followed by wavelet processing in RegiStax using gaussian wavelets (Stage 4 screenshot) to yield two images to then combine together, by using WinJUPOS to derotate them.

The combined image was then imported into PaintShopPro where the noise level was reduced by using a gaussian blur of 0.5 pixels and a Topaz DeNoise plug-in. I often use another great plug-in, Astra Image, to add a bit of deconvolution, which helps bring out detail. But it also boosts the noise, so I had to apply the finishing touches with some more gaussian blurring to smooth it. My finished 'Black Saturn' image was now ready to enter into the IAPY competition.



Martin Lewis is a planetary imager. He was shortlisted at the IAPY in 2019 for 'Black Saturn'

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△ Barnard's Loop

**PHOTO
OF THE
MONTH**

Samy Al Olabi, Wadi Shawkah, United Arab Emirates, 25 December 2019, 25 January & 21 February 2020



Samy says: "I took this photo – Barnard's Loop, framing the majority of the Orion constellation – from Wadi Shawkah (Valley of Shawkah) in the eastern parts of the UAE, around 100km from Dubai. Orion contains amazing deep-sky objects and stargazing targets. I wanted to break the trend and shot a wide-field capture that includes Orion and the Horsehead, Flame, Running Man and M78 nebulae.

This is part of a conceptual astrophotography project all about practicality and portability. I am trying to get perfect results from simple setups involving light mounts, DSLR cameras and lenses, without any kind of guiding – keeping it simple. I believe it is paying off."

Equipment: Nikon D810A DSLR, 135mm f/2 Zeiss lens, iOptron CEM25-EC mount
Exposure: 6 hours, 150 light frames (1.5–3'

each), 75 darks, 75 bias, 30 flats
Software: DeepSkyStacker, Sequator, GIMP, Photoshop

Samy's top tips: "The Orion Nebula and the stars around it are easy to see with the naked eye, but interstellar gases are hard to reveal. I took shorter exposures with a higher ISO and faster aperture. By increasing the number of light frames and calibration frames, I reduced noise and increased the signal-to-noise ratio."



△ Geomagnetic storm

Carl Gallagher, Hvammstangi, Iceland, 19 February 2020



Carl says: "At 3am I woke to see stars and what looked like wispy clouds, but they were moving too quickly. We jumped into clothes and drove on ice-covered roads to Hvammstangi on the coast, 15 minutes away. We couldn't believe our luck – the sky was alive in all directions. We had chanced upon a Kp5/G1 geomagnetic storm on our first night in Iceland!"

Equipment: Canon EOS 6D Mk II DSLR mount **Exposure:** 10" **Software:** Lightroom



△ The Straight Wall

John Brown, Leicester, 3 March 2020



John says: "I took this from my back garden. I wanted to try the Straight Wall (Rupes Recta) with a 2x Barlow after seeing it in Patrick Moore's *Guide to the Moon*."

Equipment: ZWO ASI 290MC, Sky-Watcher Skymax-127T, Sky-Watcher AZ-GTi mount **Exposure:** 120", 9,851 frames, best 10% stacked **Software:** FireCapture, AutoStakkert!, RegiStax, Photoshop



△ Pacman Nebula

Jordan Allen, Rushden, Northamptonshire, January & February 2020



Jordan says: "After shooting 20-plus hours of data over two months using narrowband clip-in filters, I ended up processing 15 hours' worth of subs and this is the end result."

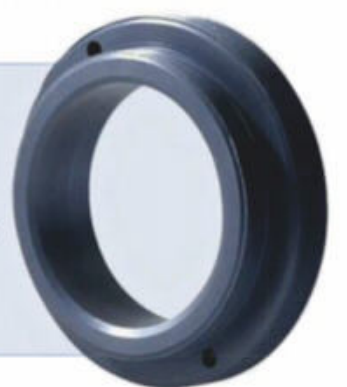
Equipment: Canon EOS 750Da DSLR, Sky-Watcher Esprit 80 ED apo refractor, Sky-Watcher HEQ5 Pro mount **Exposure:** ISO 800, 60 x 300" each Ha, OIII and SII **Software:** PixInsight, Creative Cloud

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We've teamed up with Modern Astronomy to offer the winner of next month's Gallery a finder-guider adaptor, which connects T-thread guide cameras from ZWO, Orion and others to 9 x 50 standard finders from Sky-Watcher. The accessory comes with full instructions and support. www.modernastronomy.com • 020 8763 9953

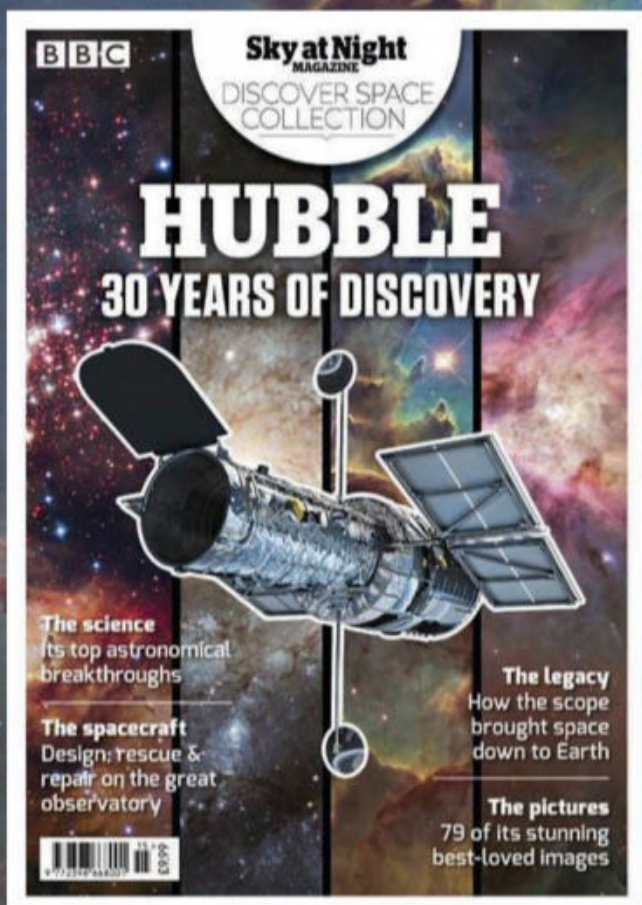


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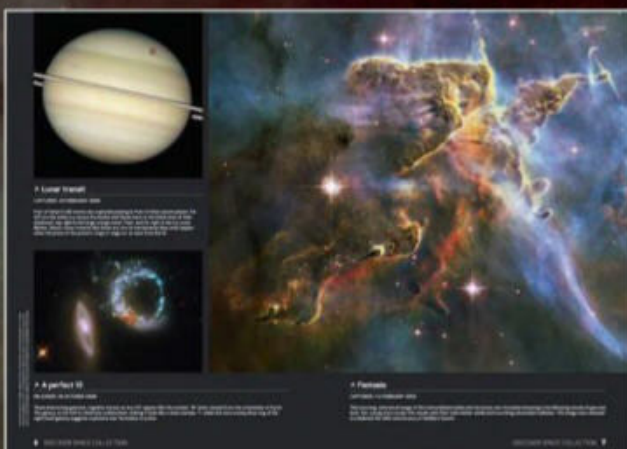


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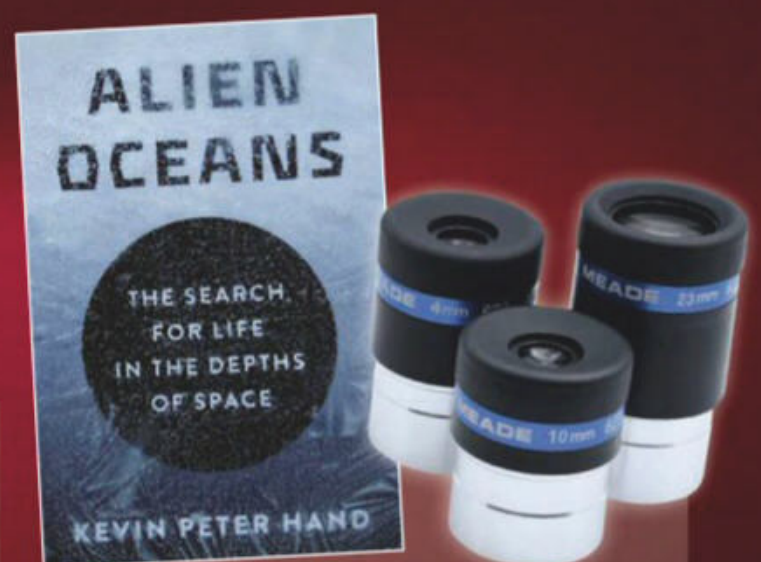
The SharpStar 20032PNT Newtonian reflector may be a fast mover, but how did it get on in typical winter weather when gaps in the clouds are few and far between?



HOW WE RATE

Each product we review is rated for performance in five categories.
Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid



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Our experts review the latest kit

FIRST LIGHT

SharpStar 20032PNT 200mm superfast f/3.2 Newtonian reflector

An easy-to-assemble telescope that combines stylish design with detailed results

WORDS: GARY PALMER

VITAL STATS

- **Price** £2,469
- **Optics**
Paraboloid Newtonian reflector
- **Aperture**
200mm
- **Focal length**
760mm f/3.8 (640mm, f/3.2 with the built-in reducing coma corrector)
- **Focuser** 3-inch rack & pinion precision focuser
- **Extras**
Tube rings, Losmandy plate, carry handle and flight case
- **Weight** 9.46kg
- **Length** 633cm
- **Supplier**
365astronomy
- **Tel** 020 3384 5187
- **www.365astronomy.com**

SharpStar is a relatively new brand in the UK, but it has been growing in popularity around the world. This is down to its equipment looking good and its reputation for high quality construction, so we were quite eager to review its 20032PNT 200mm super-fast f/3.2 Newtonian reflector. There is a lot to take in on the specifications sheet and when we opened the included flight case we were far from disappointed with the telescope's looks.

Inside we found a carbon fibre tube equipped with anodised aluminium tube rings, Losmandy plate, carry handle and matching dust cover, along with a 3-inch focuser and a 1.25-inch adaptor. On the base plate is a fan with a switch and a slot to fit the included hygrometer that is used to measure dew point and temperature. The switch marked 'heater' is not connected to anything but is ready if you want to install a heater on the scope yourself. Opening the dust cover reveals a well-finished inside, with a solid thin spider vane holding the secondary mirror in place.

One thing that can put some users off using a fast Newtonian telescope is the collimation, but once mounted this was easily achieved with the chunky collimation bolts; the short length of the tube made them easier to reach. While the scope is really for imaging, we started off the review with a look through an eyepiece and got some pleasant views of different objects in the sky.

Get the picture

Moving on to test the scope's primary purpose, its imaging capabilities, we then removed its eyepiece holder to set up a camera. Having a built-in coma corrector, the back focus must be set for it to work correctly. Depending on the size of camera attachments there are two adaptor sizes for the back focus: an M54x0.75 thread giving 55mm of back focus, and the more common M48x0.75 thread adaptor that gives 52mm. However your equipment may need different adaptors to get the correct spacing. ►

Outstanding optics

Much thought has been put into the optical system on the 20032PNT, using a 200mm, f/3.8 paraboloid primary mirror and a short-axis 90mm plane secondary mirror. The primary mirror is made of PZ33 which is very similar to Pyrex, then primary and secondary mirrors are coated in a reinforced aluminium coating which helps to give high reflectivity. This all leads to a very fast f/3.2 system that holds collimation very well during temperature changes or general moving around. Included with the telescope is an air-spaced quartette coma corrector/reducer that is screwed into the focuser. The reducing side is 0.8x, taking the focal length of the scope from 760mm to 640mm and making full-frame photography achievable and with excellent perimeter dimming control there is minimal vignetting. To collimate the telescope, the top of the focuser is unscrewed and the coma corrector has to be removed. There is an eyepiece holder included that can then be attached, allowing a collimating device to be inserted that makes the collimation process simple.



SCALE



Spider vain

The spider vain that holds the secondary mirror in place is constructed from one piece of aluminium, making the mirror's position firm. With the scope working at $f/3.2$ it's essential to have good collimation. The spider vain helps maintain collimation when the scope is being moved between locations.

Focuser

A 3-inch dual-speed rack and pinion focuser with 10:1 fine focus is fitted to the telescope. It has two lock screws to keep a good focus on targets over the duration of imaging. It can also rotate to help frame any targets. We have to admit it's a very nice focuser to use, being very smooth and precise.

Tube rings, Losmandy plate, carry handle

The tube rings, Losmandy-style plate and carry handle give the telescope a striking colour. These are all anodised in red to match the cover and are moulded with holes in to keep weight to a minimum. The carry handle has a slot to allow the mounting of other accessories.

Fan

Built into the bottom of the telescope is a fan with a switch to turn it on. It's powered by a 12V power source. Running the fan for a while before an imaging session will help stabilise the air currents inside the scope. There is also a hygrometer included to monitor dew point and temperature.



FIRST LIGHT

KIT TO ADD

- 1. ZWO 60mm finder and guide scope 60280 – dual base
- 2. ZWO EAF (Electronic Automatic Focusmotor)
- 3. 365 Astronomy Bahtinov focusing mask 250–290mm

► Normally, reviewing a product is quite straightforward, however this review was frustrated from an imaging standpoint with stormy weather rolling in for weeks and any clear nights filled with snow showers. On the plus side this telescope is very fast, which meant we could reduce the imaging times on objects and grab any small gaps in the cloud that appeared.

Quick off the mark

Our first target for imaging was well placed with very bright stars

– the constellation of Orion. It's a helpful target as it shows any off-axis light that is scattered inside the telescope, and that then appears in the images. With a short capture run of 30x30 seconds it was nice to see no reflections in the images. Due to a bright Moon, we had to wait a few weeks for a suitable night to continue our tests. We changed the camera for one with a wider field of view and chose the Whirlpool Galaxy, M51, and Leo Triplet as our next targets.

Having dodged the high clouds that were moving past, we found the resulting images showed how capable this telescope is. We even caught a quick image of the Moon through a cloud break.

Once the processing on the images was complete it was rewarding to see the amount of detail that had been captured, considering the weather and the short exposures used. The image of the Whirlpool Galaxy had nice structural detail and a few smaller galaxies could be seen close by. Again, with the Leo Triplet – where quite a lot of high cloud moved through – we were able to capture a presentable image, despite it only consisting of a set of 30x30 second exposures. By far the nicest image was Orion, with the SharpStar capturing nice colour and good detail in the final image.

The SharpStar 20032PNT is a pleasant telescope to use and no one could be disappointed with the build quality or its imaging quality. There is only one small thing that would be nice to see included and that is a finderscope. 🌌



Sturdy carrying case



▲ The Whirlpool Galaxy, M51, captured with a colour CMOS camera with no filters, using a 30x30\"/>

A full-sized flight case is included to keep everything safe when you are storing or travelling with the telescope. There is plenty of room inside so the scope can go straight in the case without removing any of the included accessories. It's also lined with a soft-feel foam.



► The Orion Nebula, captured with a colour CMOS camera with no filters, using a 30x30\"/>

VERDICT

Build & design	★★★★★
Ease of use	★★★★★
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★★

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Our experts review the latest kit

FIRST LIGHT

Orion Monster Parallelogram mount and GiantView 25x100 binoculars kit

A well-balanced and versatile observing system that delivers deep-sky results

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £805.99
- **Optics** Fully multicoated
- **Aperture and magnification** 100mm, 25x
- **Prisms** BAK-4
- **Angular field of view** 2.5°
- **Eye relief** 18mm
- **Interpupillary distance** 61–72mm
- **Focusing** Individual eyepiece focus
- **Mount load capacity** 7kg
- **Mount elevation range** 75cm
- **Weight** Binoculars 4.6kg; mount and tripod 20.4kg
- **Supplier** Orion Telescopes & Binoculars
- **Tel** 0800 0418146
- **https://uk.telescope.com/**

Well-mounted large aperture binoculars are a joy to use, especially for the larger deep-sky objects, so Orion's new binocular and parallelogram combo piqued our interest. The GiantView 25x100 binoculars, which come in an aluminium case, have a Porro-prism individual-eyepiece focusing design that is covered with a thin rubber armour. There is a longitudinal bar that connects the hinge to cuffs on the objective cells. This bar increases the rigidity of the binoculars and carries a sliding mounting post that enables you to achieve perfect balance when you mount them. But, at the point of perfect balance, it obstructs the minimum achievable interpupillary distance (IPD) – the distance between the pupils of your eyes – to 66mm.

When we looked down the objective tubes, we saw that the prisms are secured in proper cages, not merely clipped to the housing, so they should not become dislodged by minor bumps. The entrance to the prism

housing does not restrict the light path, so that light from the full 100mm aperture is transmitted to the eyepiece. This examination also revealed that the insides of the objective tubes are smooth and without light baffles, although they are stepped where the objective tubes join with the objective cells and delete prism housings. This means that stray light is not well controlled, to the extent that it is intrusive when, for example, a first quarter Moon is within about 5° of the target area of sky. We didn't notice this stray light from any stars, but it must cause some reduction in contrast.

Enjoying the sights

We thoroughly enjoyed our first stargazing outing – as we put the binoculars and mount to the test – and targeted the constellation of Orion, the Hunter. The Orion Nebula, M42, was bright, with a structure that seemed to increase in detail the longer we examined it. The Trapezium Cluster was cleanly split as we moved it over the central third of the field of view. We found the colour rendition was very good with recently dimmed ▶

Versatile viewing

Do you sometimes share the night sky with others? When you observe alone, do you prefer to observe standing, seated, or reclined? Do you sometimes wonder what your target object would look like through a different instrument? Here's a binocular and mount observing kit that has it all. Without any additional outlay, or using any tools, you can instantly adjust your mount for people of different heights, and the perfect balance of the binoculars ensures that they will still be pointed at the same target. You can walk around the tripod, flitting from target to target, enjoying the variety of what these big objective lenses can show you or, as the mood takes you, pull up a garden recliner and, in comfort, examine an object or a region of sky in detail and depth. The Vixen–Skywatcher compatible dovetail block on the mount not only enables you to achieve perfect balance of the 25x100 binoculars but, if you are wondering how the views in another instrument compare, it will also accept any compatible scope.



SCALE



Locking lever

For security, it is essential that the attachment of the mounting post of these heavy binoculars cannot loosen while they are in use. The hand-wheel on the mounting bracket can give you reasonable tightness, but the locking lever, with mere thumb pressure, provides the extra security that you need.



Adjustable friction

Orion provides the instructions and tools to enable you to adjust the friction in the parallelogram motions. This enables you to set it low for the 'floating binocular' sensation, or to increase it for, say, windy nights or outreach events where it might be susceptible to being nudged.



FIRST LIGHT

KIT TO ADD

1. Orion Binocular Astronomy Field Guide
2. 4.57" ID set of Orion binoculars solar filters
3. Orion Moon and Planets Guide Set

► Betelgeuse looking ruddy. We also tried some galaxies in Ursa Major: the Whirlpool, M51, revealed both of its core structures, and the Pinwheel, M101, was easy to see despite its low altitude. Open clusters, however, are the real strength of these mounted binoculars. While the Pleiades, M45, was as stunning as we expected, we spent a long time enjoying the

Messier clusters in Auriga and Gemini and had to drag ourselves away from the Milky Way's Cassiopeia region.

Perfect balance

Given the weight of these binoculars, this enjoyment was only made possible by Orion's Monster Parallelogram mount. It has some nice touches, one of which is the facility to vertically adjust the mounting bracket in order to achieve perfect balance: you won't find any positions in which the binoculars refuse to stay put without you over-tightening the mount's joints. This makes it easy to achieve that 'floating binocular' effect that is the hallmark of a good parallelogram mount. The helpful instructions are detailed and well-illustrated.

The tripod is a Synta-made model with 1.75-inch diameter legs, and a north pin (initially for equatorial mounts) which is used to prevent the parallelogram from unscrewing itself. The mount arms measure 57cm between fulcrums, giving a vertical range of 75cm, making it easy to share views with people of various heights. There is some vibration when you change target, but this dies down in seconds. There are two counterweights and you can experiment with their positions to achieve a short vibration-damping time.

When the binoculars are pointed vertically with the tripod extended, the eyepiece height is a maximum of 148cm. Orion suggests purchasing an extension pier for the mount, but you can use a garden recliner, as lying back makes high-altitude observing more comfortable.

This is a complete observing system that will suit anyone who wants a reasonably priced step-up to big mounted binoculars, using a mount that can take other astronomical instruments and which has the versatility to make it ideal for sharing the night sky with others. 🌌

VERDICT

Build & Design	★★★★★
Ease of Use	★★★★★
Features	★★★★★
Optics	★★★★★
Stability	★★★★★
OVERALL	★★★★★



Fully
multicoated optics

Broadband multicoatings increase light throughput and also reduce the likelihood of internal reflections forming ghost images. They allow the maximum amount of light collected by the large objective lenses to pass to your eyes, giving you maximum brightness with a minimum of distracting 'ghosts'.

Mini dovetail

Perfect balance requires that the load's centre of mass is in line with the altitude fulcrum, which is usually impossible to achieve with L-bracket mounted binoculars. Orion has solved this by providing a mini-dovetail that enables the necessary forward-and-back adjustment, enabling perfectly balanced mounting of small binoculars.



Individual eyepiece focusing

For astronomical use, individual eyepiece focusing is considered to be superior to centre-focusing, largely because it is far less easy to accidentally change the focus. Once you are focused, you don't need to refocus on different astronomical objects, so you don't need the terrestrial convenience of centre-focus.



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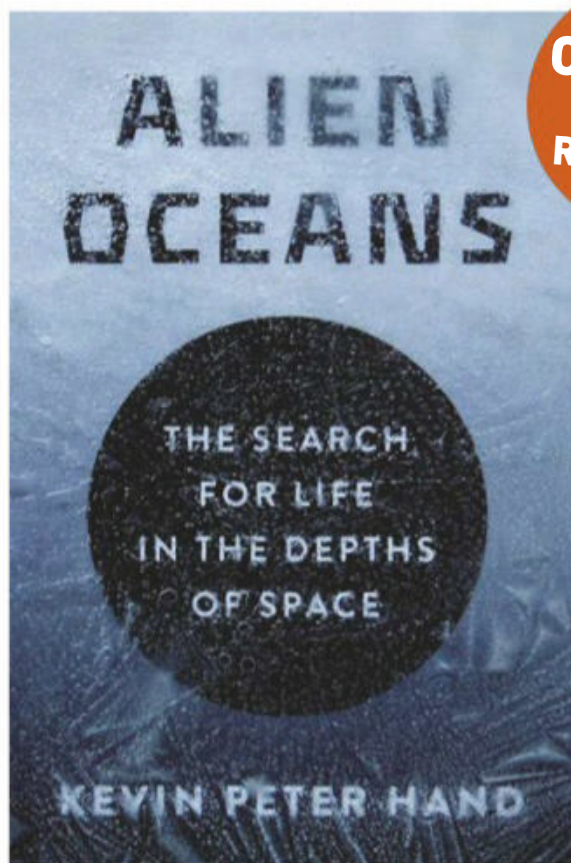


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BOOKS



**CUTTING
EDGE
RESEARCH**

could reconstruct details of Europa's internal structure and determine that the surface layer of low-density water-ice is 100–200km thick.

We can also tell that at least some of that ice shell has melted. The Galileo probe sensed disturbances to Jupiter's magnetic field from something electrically conductive beneath Europa's face: a layer of salty liquid water. Europa's subsurface ocean was distinguished in just the same way that an airport security scanner detects unseen metal objects on your person.

But it's still a mystery as to how often this hidden ocean might be squeezed up and come into contact with the surface. Are the sulphur compounds we can map across the moon's face indicative of an upwelling of salty ocean water from below, or just sputtering from the volcanoes of Io? Whether Europa's ice shell is thin or thick is hotly controversial, as Hand reports, and is a crucial aspect of whether this dark ocean might be habitable for alien life or not.

Hand also deals with the Cassini probe tasting the sea water erupting in the plumes of Enceladus, and the chance of truly alien life in Titan's hydrocarbon lakes.

What is so captivating about this book is that it isn't just a solid survey of what we've learned in recent decades about the icy moons, but that the narrative is told by an active researcher deeply embedded in these endeavours. Through Hand's eyes we meet many of the key personalities involved and feel the sting of

disappointment at cancelled funding or a malfunctioning probe, as well as the soaring excitement of a new discovery. ★★★★★

Lewis Dartnell is an astrobiologist at the University of Westminster, a science communicator and author

Interview with the author Kevin Peter Hand



Why study icy ocean worlds?

If we've learned anything from life on Earth it's that where you find liquid water, you generally find life. The exciting question for me and my colleagues is, if there's that much liquid water out in these alien oceans, could there be life?

Would a sample return mission to these worlds be possible?

Time and gravity are a real pain in the neck when you're thinking about doing sample return missions. With Europa it would mean getting to the surface, gathering a sample, then launching a spacecraft that can escape Jupiter's gravity to get back to Earth. Also, we have strict regulations to make sure we don't contaminate that world or affect our measurements by detecting a microbe we brought with us. And bringing a sample back to Earth puts up a huge barrier of making sure we contain that sample and protect our planet from an alien organism.

What might intelligent life in an alien ocean be like?

Think about how our ability to look up at the night sky has motivated our desire to explore. If there were intelligent life in an ocean like Europa's, it wouldn't be able to see the night sky. Above would be an ice shell creaking and cracking from tidal energy dissipation, so it could have a limited understanding of its place in the cosmos. How does that manifest itself in the evolution of intelligence? How does curiosity come about in an intelligent organism that doesn't know to ask the question "are we alone?"

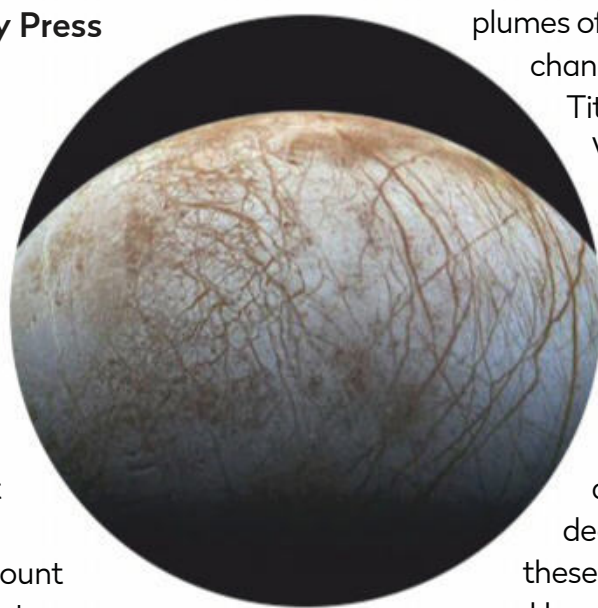
Kevin Peter Hand is a scientist at NASA's Jet Propulsion Laboratory who is currently leading an effort to land a spacecraft on Europa

Alien Oceans: The Search for Life in the Depths of Space

Kevin Peter Hand
Princeton University Press
£22 • HB

Some of the most promising targets for finding extraterrestrial life are the icy moons orbiting Jupiter and Saturn. Kevin Peter Hand is a leading scientist at NASA's Jet Propulsion Laboratory and in this thrilling account he gives us an insight into efforts to explore these alien oceans.

One potential abode is Jupiter's moon Europa. Hand explains the intricate calculations performed by the radio-tracking team for the Galileo space probe, who during flybys of Europa were able to measure shifts in the craft's velocity of millimetres per second. From this they



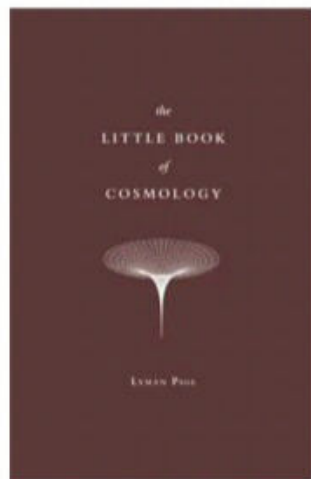
▲ Are there traces of life in the salty ocean below Europa?

The Little Book of Cosmology

Lyman Page

Princeton University Press

£16.99 • HB



The Little Book of Cosmology is certainly little; it could very well get lost in your bag. In around 100 pages it explores the composition, geometry and evolution of the Universe,

as well as the frontiers of cosmology. Isn't it marvellous to think that "we can understand the Universe at its grandest scales to per cent-level accuracy through measurement".

The Little Book does contain everything that you would expect to find given the title, and for that it is to be commended, however some may feel there is something lacking.

The writer does warn the reader early

on that he is expecting some knowledge and interest in cosmology, but the pace of the book flips quickly between beginner and intermediate levels, and in places it can be confusing to grasp what the text is referring to. On a positive note, there are some nice analogies and the book certainly won't take you long to get through.

But what is missing most from this book is inspiration. Every reader wants to come away from a popular science book with some sense of awe, and a hunger to delve deeper. After all, the evolution of the Universe and how we've figured it all out is extremely exciting. But this was not the case here; perhaps it's harder to achieve in so few pages. However it's certainly a nice little book for those who have some knowledge of the subject.

★★★★★

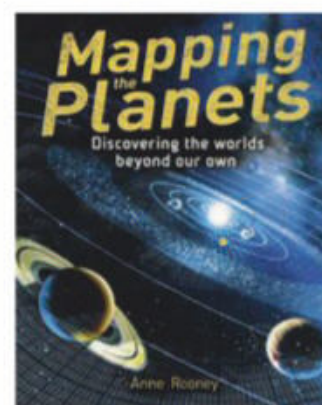
Laura Nuttall is a senior lecturer in gravitational waves at the University of Portsmouth

Mapping the Planets: Discovering the Worlds Beyond Our Own

Anne Rooney

Arcturus

£14.99 • HB



Leafing through Anne Rooney's travelogue of the Solar System, you have to pinch yourself to realise that four centuries ago the worlds beyond Earth

were known only as far-off points of light in a velvet sky. Within a few dozen generations, our eyes have been opened to what science writer and academic Rooney calls "a different type of mapping". For the first time, astronomers moved beyond working out the orbits of the planets and recognised them as a brotherhood of dissimilar worlds, forged from the same melting pot as our own.

In *Mapping the Planets*, Rooney shines a light on our ancestors who first noticed the non-twinkling characteristic of what the Greeks called planetos; 'wanderers' which inexplicably moved in predictable patterns. She introduces us to ancient and medieval sky watchers and heated rivalries between the Ptolemaic and Copernican concepts of the cosmos, which presaged the birth of the telescope.

Rooney uncannily delights us at each turn of the page, stripping away the Solar System's mysteries like an onion skin and firing our innate sense of wonder. She astounds us with the size and scale of the Sun's worlds of rock and ice, their physical appearance thanks to visiting space probes, their complex surfaces thanks to rovers and landers and their contribution to understanding how we came to be. Reinforced by a gorgeous array of eye-popping imagery, Rooney's well-crafted story juxtaposes the authority of a scientist with the eye of an artist and the wonder of a child.

★★★★★

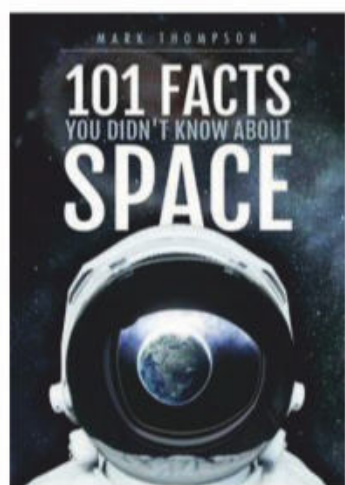
Ben Evans is the author of several books on human spaceflight and is a science and astronomy writer

101 Facts You Didn't Know About Space

Mark Thompson

White Owl

£25 • HB



Did you know that in 140 million years' time, our standard Earth day of just under 24 hours will be one hour longer? Or that metals stick to each

other in the vacuum of space? Or even that some gas clouds in space contain enough alcohol for everyone in the world for a billion years?

These are just three of the 101 very interesting facts discussed in Mark Thompson's well-presented astronomical and space exploration miscellany, *101 Facts You Didn't Know About Space*.

This easy, fun and digestible list of facts can be explored in any order the reader might wish. Thompson pretty

much dives immediately into explaining fact after fact, writing in a light prose style that provides the context for each topic, and each piece of fascinating science is supported throughout with pleasing visual imagery. Some of the facts presented were not new to this reader and are extensively covered in other reference books, but other readers may feel differently. Thompson makes up for it, however, by providing plenty of other genuinely novel facts on topics such as copulation methods in space, the retrograde orbits of some planets and the absence of 'holes' in 'black holes'.

An introductory chapter outlining the process of how the author selected these 101 facts would have added an extra dimension to the book. Having said that, this is still a good read and there's something for all levels of space enthusiast, from young adults to more experienced readers. ★★★★★

Niamh Shaw is an engineer, lecturer and science communicator

Ezzy Pearson rounds up the latest astronomical accessories

GEAR



1 Explore Scientific professional weather centre

Price £328 • **Supplier** Telescope House
Tel 01342 837098 • www.telescopehouse.com

ADVANCED

Predict whether a clear night might be on the way with the help of this digital weather station. The 7-in-1 sensor is capable of detecting temperature, wind speed, air pressure and sunlight and then clearly displays its findings on a colour LED screen.

2 Bamboo thermal flask

Price £22 • **Supplier** Stolen Goat •
www.stolengoat.com

A late observing session is always easier with a hot tea or coffee to keep you going. This bamboo flask will help keep your drinks warm for up to 10 hours, and its curved shape makes it easier to grip even while wearing gloves.

3 Meade wide-angle eyepiece set

Price £39 • **Supplier** Opticstar • www.opticstar.com

These affordable eyepieces are a great buy for any beginner. Their generous 62° field of view allows you to take a better look at large night-sky objects. The set comes with a padded storage box to protect them when not in use.

4 Stars large notebook

Price £12.99 • **Supplier** Waterstones
www.waterstones.com

This notebook, decorated with depictions of the constellations, is the perfect place to log your observations and keep track of what you see in the night sky. It contains 160 lined pages.

5 William Optics dual-sided mounting plates

Price £24.99 • **Supplier** The Widescreen Centre
Tel 01353 776199 • www.widescreen-centre.co.uk

These dual-sided mounting plates fit all Vixen-style fixtures on one side, then can be flipped over to hold Arca Swiss types on the other side. The bright coatings help to protect the metal while giving your setup a colourful flourish.

6 NASA JM patch hoodie

Price £24.99 • **Supplier** IWOOT
www.iwantoneofthose.com

Whether outside looking at the night sky or sitting at home watching *The Sky at Night* on TV, this hoodie is a great way to keep warm, comfortable and stylish while also showing off your love of all things space.

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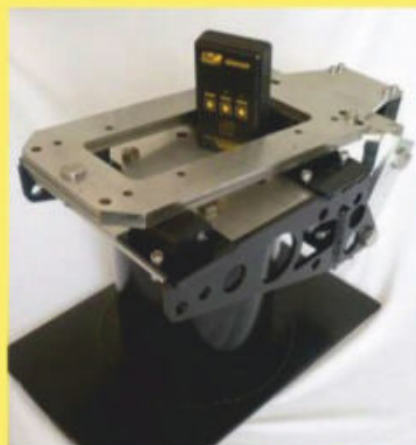
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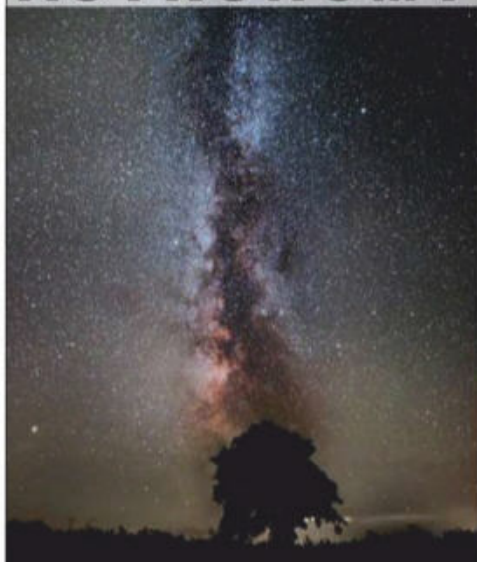
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Q&A WITH AN EXOPLANET SCIENTIST

We had yet to find an exoplanet when Hubble launched, but 30 years later the telescope is helping to reveal the atmospheres of these distant worlds

How do you use Hubble to explore the atmospheres of exoplanets?

We use Hubble to look at planets while they pass in front of their star. If the planet has an atmosphere, some of the star's light will shine through it before reaching our telescope. That light will change as different colours are absorbed depending on what makes up the atmosphere. We're able to measure the way the planet's atmosphere blocks the star's light and work out what's in it.

Why do you use Hubble?

We use the Hubble Space Telescope because we are sitting inside an atmosphere. If you want to look for things such as water vapour, then our own atmosphere is also filled with water vapour and that gets in the way. Hubble sits outside the atmosphere, which means we don't have to worry about the gases in the air getting in the way.

What are you looking for in an exoplanet's atmosphere?

It's different depending on what type of planet we are looking at. Many of the planets we've been studying in detail are these Jupiter-sized worlds that are very close to their stars, 'hot Jupiters'. Here we're looking for hot water vapour.

For smaller worlds, those roughly the size of Neptune or smaller, we're still looking for water vapour, but we're determining whether they are planets like Earth and Venus or if they're more like Jupiter.

How do you choose which planets will get followed up with Hubble?

It can be based on a particular question that we want answered. But honestly, it's whichever ones we can get a good signal for. There are thousands of worlds that have been discovered, but there's only a few hundred of these that we can observe easily with our telescope. These are really difficult measurements to make but we will observe it again and again if we have to until we can get that signal.



▲ **Some like it hot:** Hubble has discovered many 'hot Jupiters' that orbit perilously close to their host stars

of these exoplanet atmospheres are so hot, they're so close to their star, the clouds we expect to form there are not liquid drops of water, but tiny pieces of rock suspended in the atmosphere. It's exciting because these clouds are made of glass, rubies, sapphires – gems that we find on Earth.

Why should we study exoplanet atmospheres?

We don't have an idea what a planetary system should look like. If you look at the Solar System you see four small planets and then four giant planets. Is that normal? Venus is almost the same mass and radius as Earth. Remove that from our Solar System and we would assume that an exoplanet that was the mass and radius of Earth must be like Earth. But we have an example in our Solar System where that's not the case. Exoplanets enable us to take what we know from our Solar System and turn it on its head. What happened to make these 'hot Jupiters' that didn't happen in our Solar System?

How long will Hubble continue observing exoplanets?

Hubble is going to be working for us for the next five years at least. It's a fantastic instrument, but it's also limited. In the future we're going to get the James Webb Space Telescope, launching in 2021. It will have a much larger 6.5m telescope. We'll be able to measure exoplanets in more detail and look at the water vapour in the atmosphere, alongside the carbon dioxide, methane or carbon monoxide that we haven't been able to measure. Combining what we're learning right now with what we measure in the future is going to be important for evolving the field of exoplanet research.



Dr Hannah Wakeford is an astrophysics lecturer at the University of Bristol where she researches the atmospheres of exoplanets by using the Hubble Space Telescope.



Thank you, Sylvia

Sylvia left a gift in her Will to help conquer Stroke

The first we knew of Sylvia was when we received notification of the gift she'd left us in her Will. Shortly after, a beautiful story of a much-loved woman began to unfurl.

Friends remembered Sylvia's kind-heart and her wish to help others. She spent part of her adult-life caring for her mother, and developed a passion

for medicine. Becoming a medical secretary was her next step and, in the course of her career, she discovered the devastating impact a stroke could have on people and their families. She saw that research and treatment were vastly under-funded, and she decided to remember the Stroke Association in her Will.

Sylvia's gift has helped fund our work to conquer stroke. She's supported research to prevent and treat stroke, and she's helped care for survivors. And that's something you can do too – in the same way.

If you would like to learn more about remembering the Stroke Association in your Will, please get in touch.

**Call 020 75661505 email legacy@stroke.org.uk
or visit stroke.org.uk/legacy**

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Stroke
association

THE SOUTHERN HEMISPHERE



With Glenn Dawes

The Moon tours five naked-eye planets and the northern sky is dominated by bright evening stars

When to use this chart

1 May at 24:00 AEDT (13:00 UT)
15 May at 23:00 AEDT (12:00 UT)
31 May at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

MAY HIGHLIGHTS

Watch the Moon tour the five naked-eye planets in May. On the 12th, the gibbous (20-day old) Moon is low in the late eastern evening sky, forming a triangle with Jupiter and Saturn. It continues into the morning sky, where the near third quarter Moon meets Mars. It's directly above on the 15th and below the following day. On the 24th, the Moon's thin crescent returns to the western twilight sky where it forms a triangle with Mercury and Venus, in the Sun's glow.

STARS AND CONSTELLATIONS

If you can tear yourself away from the southern Milky Way, the northern evening sky is dominated by two bright stars. The lower is Arcturus (Alpha Bootes). Shining at mag. +0.1 this 'cool' (4,300K) orange-coloured giant star is the fourth brightest in the night sky. The other is the dimmer mag. +1.0 Spica (Alpha Virginis). Its blue colour hints at a different star, being hotter (16,000K) and more luminous than Arcturus. If Spica was the same distance as Arcturus, it would outshine Jupiter!

THE PLANETS

Venus's dominance of the western evening sky comes to an end, becoming a twilight-only object by mid-May and gone by month's end. During its departure, it's passed by Mercury on 22nd as this innermost world makes an

evening return. Next is Jupiter, around 21:30, followed by Saturn – these gas giants transit in the pre-dawn. In the morning Mars rises around midnight (midmonth), followed by Neptune two hours later. Uranus returns to the morning, out of the midmonth dawn.

DEEP-SKY OBJECTS

M49 or NGC 4472 (RA 12h 29.8m, dec. +8° 00') is a bright (+8.4 magnitude) galaxy in Virgo, appearing similar to the better-known M87 (located 4.5° due north, at the centre of the Coma-Virgo Galaxy Cluster). Being an elliptical, M49 visually fits the stereotype comparison to an unresolved globular cluster, having an obvious round (3') halo, quickly brightening as you approach its intense core.

Move 1° to the east of M49 and discover a pair of 10th magnitude spirals, NGC 4526 and 4535. The southern galaxy, 4526, is easily recognised being flanked by two bright (7th magnitude) stars both 0.1° away. It has an elongated (3' long) diffuse halo with a bright core and faint stellar nucleus. Its companion, 4535 (0.5° north) is quite different having a fainter and more circular, mottled halo (4' across) with only a slight central brightening.

Chart key

GALAXY	DIFFUSE NEBULOSITY	ASTEROID TRACK	STAR BRIGHTNESS: ● MAG. 0 & BRIGHTER ● MAG. +1 ● MAG. +2 ● MAG. +3 ● MAG. +4 & FAINTER
OPEN CLUSTER	DOUBLE STAR	METEOR RADIANT	
GLOBULAR CLUSTER	VARIABLE STAR	QUASAR	
PLANETARY NEBULA	COMET TRACK	PLANET	

